The Democratic Republic Of The Sudan

Basline Survey and Monitoring programme for North Kordofan rural Water Supply projeet

prepared By

The Institute Of Envieromatal Studies

University Of Khartoum

For

The Cooperative American Relief Everywhere

(CARE)

By

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Khartoum 1982

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SUMMERY

Control Measures

All development projects have environmental and economic consequences. The social and environmental effects of water development in a particular site may extend further than the planning area itself. At the same time any control measures to reduce or control the negative impacts will have effects beyond the planning area and may have effects at the national level. Thereforedecisions regarding these measures are to be taken at different levels of authority. Some decisions may be taken and implemented by the regional authorities; others require decisions at the national level.

This study highlighted some of the environmental problems in the project area and raised issues regarding water supplies and its impacts on the physical and biological systems. It went further to assess methods of water delivery and evaluated the views of the users with respect to the type of water they get; their evaluation of environmental conditions; factors contributing to environmental degredation and how to control it. The results of our surveys enables us to suggest some measures which we hope, if properly implemented, will have positive effects in minimizing or reducing the

negative impacts of water supplies on the environment. Most of the ideas suggested here are the result of long discussions with the local communities as well as decision makers.

The study showed that water supplies alone - per se - will not cause negative environmental impacts, but the human use of resources and methods of water handling are the main causes. Water must be considered as one element in a number of interrelated factors working together to bring change in rural areas. The most important among these are :

1- Increase in both human and animal populations upsetting the delicate ecological balance that existed for years. That balance was maintained through the traditional strategies and methods of resource management and land use. Traditional form of land use has built in mechanisms to achieve ecological balance in the form of long fallow periods to allow plant regeneration. With population and animal increase as a result of external factors - medical and veterinary services - the fallow period was reduced and more grazing pressure was felt. Thus the areas under hashab trees, which was incorporated in the rotation, diminished in size.

2- Rural areas also experienced some form of economic change - change from subsistence mode of production to peasant form of economy - involving a large measure of commercialization and more involvement in the market economy. This feature resulted in the rise in levels of wants and aspirations for better life. To achieve these aims, they started to produce more which was achieved by opening additional land for cultivation without any form of intensification or change in the methods of production. As population increase accelerated, some form of land scarcity is felt and so large parts are put under continous cultivation for long periods reducing soil fertility and removing vegetation cover.

3- Animal keeping in such areas is considered as an investment - the only form of investment known to such people - and it is also considered as security. Thus the traditional ways of animal keeping continued taking the advantages offered by both veterinary services and water supplies. The traditional strategy in such fragile environment is to keep more animals to provide security when crops fail. Therefore, and as animals are kept for that purpose selling is very limited. Animals did not enter the marketing system in large proportions. In this

connection we have to draw distinction between change in crop farming and animal keeping. In the field of crop farming there is more involvement in growing cash crops and use the extra cash for investing in animals to meet the uncertainities of the environment.

4- Gum collection as an economic activity is a secondary occupation practiced during the dead season. In many respects it is not a true commercial activity. It is clearly a peasant form of economic activity to get some cash to substitute for animal or crop selling. Under such circumstances, the concern for gum tapping and hashab planting is still marginal. On the other hand the Gum Arabic Co. through its marketing policy - very low prices - contributed to this lack of concern from the producer's side. This argument is supported by the results of survey which showed that hashab planting is practiced by few even in villages which requested the Forest Department to provide them with hashab seedlings. It seems to us that the main incentive for that request is the promise given for water provision. Also we found that even in those villages considered with enthusiastic hashab growers, planting of hashab seedlings is given low priority with respect to crop planting.

From this discussion, it is clear that there are many factors contributing to the present environmental degradation in the area, but water provision seemed to be the most important factor creating the necessary conditions for more cultivation and animal keeping and contributes effectively in accelerating the impacts of other factors. This is so because water is provided without linking it or integrating it to other rural development programmes. Water provision has to be looked upon as complementary to integrated rural development programmes. This could be achieved by setting up a national target and clearly defined objectives for rural water development. Tied to these policies is the criteria for choosing sites for water provision. This criteria must reflect the national targets and objectives behind water provision. For example the target may be to provide water as a service and to achieve equity or to use water as a catalyst for environmental protection or to support other development projects. All these will have an important influence on sites selected and type of water provided.

The present criteria failed to achieve the objectives of proper land use and resource management. This criteria takes into consideration :

1- Human and animal population 70%

2- Potentialities of the site for development

3- Natural resource aspects?

4- Nearness to water sources 10%

5- Season of the study 10%

It is clear that this criteria is not strictly applied because of political pressure. Also the criteria gives low consideration to natural resources and environmental conditions. Thus, in order to use water to effect better resource management, the criteria must be revised to take into consideration environmental and natural resource situation.

To implement the new criteria, it requires a new approach from the part of the water providing agency. It has to take into consideration local initiation. It has to recognize that the pecple are willing to pay more for the essential services than the government is charging them and to institute a new water pricing system accordingly.

Based on this discussion and from the results of our survey, it is possible to suggest some control measures to ensure proper resource use and to reduce the negative impacts of water. In suggesting these measures we

are fully aware that some of the measures go beyond water to include matters related to the creation of the necessary institutional framework and bodies capable of co-ordination resource use. We also believe tthat controls on water provision alone will not solve the problem of environmental degredation, because the causes of the problem goes beyond water to include resource management and attempts of rural development in general. It requires co-ordinated action taken by the different departments involved in resource management. Thus the measures suggested include all those aspects which we feel feasible to be implemented in the project area. These measures are grouped under the following :

1- Institutional framework

2- Resource management

3- Water supply provision

4- Management and administration of water sources

5- Local involvement and participation.

Institutional Framework :

1. Land use planning.

At present there is neither the legislation nor the administrative capacity to control the use of land in the vicinity of the wateryards. There is need for land use plans and laws and regulations to organize the use of

natural resources. We feel that the regional governments have some of the powers to exercise such influence over land use.

2. To reinforce the forest law not through the police methods practiced today but according to working plans specifying areas for felling and areas for regeneration and creation of shelter belts to ensure a rational use of forest resources.

3. To make laws that regulate pasture utilization in accorance with pasture condition and animal pressure. It is possible to suggest rotational grazing or leave corridors for the nomads. At village levels there are attempts in this direction. In many villages the nomads are not allowed to graze in certain areas or allow their animals to graze in hashab gardens. These regulations as enforced by the villagers themselves but they need government backing to avoid serious clashes with the nomads.

4. It is found that the activities of the units working in the field of natural resource management are not co-ordinated. To remedy this immediate action must be taken at the regional level to create the institutional framework capable of co-ordinating the

activities of departments such as Range and Pasture Management, NAW, soil conservation and water programming, veterinary services and Ministry of Agriculture. This co-ordinating body must create the necessary linkages through the utilization of village organizations to ensure the flow of information down to the village level.

Resource Management :

1- To achieve better resource management in such marginal areas, water supplies may be used as catalyst to effect the change desired. Economic logic suggests concentration of investment to achieve economies of scale, while ecological logic leans towards dispersion of investments according to population and environmental conditions to spread the negative impacts. This could be achieved by providing complementary water sources in different locations e.g. haffirs in certain areas capable of holding water for 3-4 months then supplemented by a wateryard in another location to provide water for the rest of the year. This policy must be tied to the system of rotational grazing already suggested.

2- The present communal land tenure system, despite

its flexibility to accommodate the economic changes that took place in the area, but it seems to be a major obstacle to better resource management. Steps must be taken in the direction of seperating village lands from areas of open grazing. A further step may be taken towards giving free titles to hashab gardens.

3- Models and experimental farms at village level to teach the villagers proper farm husbandary and the right mix of crops. At present the traditional farming receives no guidance and it is left to market forces.

4- The wateryard and its hinterland must be resurveyed to compare the initial reconnaisance survey with conditions at the time of the second survey to enable impact assessments on the physical, human and livestock conditions. Such resurvey may suggest opening new wateryards or to expand the capacity of the old and to redefine the criteria for water provision.

3. Water Supply Provision.

1. The Criteria for water supply provision must be

revised to give more emphasis to environmental conditions and natural resource potentialities and capabilities. The suggested criteria should include

a) Environmental conditions of the area with particular emphasis on pasture conditions, vegetation cover and soils;

b) carrying capacity of the area should determine the type of the water source to be provided and the capacity;

c) potential for development in order to create growth centres and not merely service centres;

d) community awareness of environmental conditions and willingness to participate in efforts to control degredation and acceptance of any control measures that may be suggested by the water providing agency.

e) active involvement in hashab restocking programmes;

f) willingness to pay some of the costs and ability to be involved in water administration.

2. The type of water to be provided must meet the needs of the village population especially in degraded areas. This could be achieved through the creation of "Water Associations" formed from the village

population and its envelope.

3- The standard wateryard design must be abondoned in favour of a design that achieves separation between human and animal use and taking into consideration that most of the water collectors are children. We support the construction of standpipes in different parts of the village. In the project area, good example is provided by Shabula village.Regulations must be set and implemented to ensure that stand-pipes are used for human consumption only. In this connection, village organizations may be involved in the implementation of these rules and regulations.

4- Separate wateryards for animals especially in areas with high carrying capacity such as the areas in the margin between Umm Ruwaba series and Basement complex.

5- The present water pricing system must be changed. It should not be equal to all. Nomads must pay more especially in wateryards where signs of degredation are very clear. That is to make high water prices in the northern zone and relatively lower in areas with high carrying capacity to the south.

6- Alternate opening of water points. That is some water points may be opened for use early in the dry season and closed while another wateryard will be opened late in the season.

7- It is high time to abandon the approach of drilling where underground water is found. Techniques must be found to solve the water problems of the so called difficult areas, so that water is provided where it is needed according to natural resource condition.

8- Attempts should be made to introduce rain water catchment system so that rain water may be stored in cisterns especially in sany areas.

Also small tanks drawn by animals may be designed to be utilized in transporting water. The costs of these tanks may be paid by the village through its water committee.

9- Simple water treatment methods may be introduced in villages with haffirs. Research must be carried to understand fully the traditional systems of water purification in order to improve it and to diffuse its use.

10- To investigate the possibility of providing the shallow wells with hand pumps. Also to improve

water quality and to avoid contamination of the shallow wells cement raised platforms may be constructed.

4. Management and Administration.

1- Operation and maintenance must be considered and included in early phase of planning.

2- Maintenance must be decentralized, and shouldered by NAW through its regional workshops. Mobile teams must be formed and given the responsibility of maintaining certain number of wateryards.

3- NAW must establish stores, in the regional workshops, for spare parts and fuel and to furnish the maintenance teams with the necessary equipment and logistical support.

4- NAW must train the wateryard operators and try to diffuse the technonogy of wateryard maintenance to the private sector.

5- The pumps must be standarized, because this will facilitate maintenance problems.

6- Pass certain administrative responsibilities to the local community.

5, Local involvement :

1. It is truely stated by shepard (1981) that "the

On the other hand some measures and recommendations may be implemented by NAW while others require laws to be passed by the regional government. We feel that the present organizational structure of NAW in El Obeid is capable of implementing these measures. What is required is the creation of the "socio-economic" or "environmental office" to supervise the creation of the Water Committees. This action is not new because in 1969, Ministry of Rural Development and Co-operatives - which included RWD - supervised the creation of Rural Development Committees and contributed effectively to the spread of self-help concept in the Sudan.

CHAPTER I.

PROJECT DEFINITION.

Introduction :

The Institute of Environmental Studies (I.E.S.) agreed to design and carry out a baseline survey and design an environmental impact monitoring system for North Kordofan Rural Water Supply Project funded by CARE.

The team selected for this job includes experts with the following specializations :

1. Geologist.
2. Rural Development expert.
3. Geographer with experience in the field of water supplies.

They were assisted by experts specialized in Agriculture, Range and Pasture Management and Agricultural Extension.

In El Obeid other experts joined the team mainly geologists and hydrologists from Rural Water Development Corporation, Range and Pasture Management and Soil Conservation Administration.

Scope and Objectives :

The objectives of the baseline survey are to provide data and information on the following :-

1. Data on water consumption habits.
2. Data on land use and livestock and effects on each of water supplies.
3. Environmental impact which existing water supplies have on the project area.
4. To recommend control mechanisms in order to minimize the negative environmental impact of water.
5. The survey team is to examine the proposed sites for water provision and provide a list of sites in order of priority and recommendations for the type of water system to be installed.
6. To design a monitoring system for follow up studies to be used as indicators of environmental change.
7. To collaborate with CARE and NAW in drawing an operational plan for execution.

Data Collection :

To achieve these objectives, data must be collected on social, economic and environmental parameters in the project area. Three methods were employed :

a) Questionnaires.

b) Records, reports and files.

c) Observation, analysis of air photos and ground truth verification.

a) Questionnaires :

Three types were prepared :

(i) General ... to collect data-through interviewing group of villagers - on their views with regard to their water supply, environmental conditions, economic activities, habits and customs, etc..

(ii) Household questionnaire ... This questionnaire is intended to collect data on water consumption, water use, water collection, involvement in management etc.. Only some randomly selected villagers were interviewed.

(iii) Well site observation ... A sheet was prepared including items to be observed in the wateryard such as general condition, number of people and animals, condition of pumps, tanks, troughs; people and animal from other villages using the source etc..

b) Records and Reports :

Both in El Obeid and in Khartoum a lot of information is found in reports and files of the Rural Water Corporation. These records provide information on type of sources, location, water yield, breakdowns and maintenance etc..

c) Air Photos and Observation :

The project area is well covered by air photographs and satellite imagery. The team obtained air photographs taken in 1965 and satallite images taken in 1975. This time span enabled the survey team to compare the present environmental conditions with those of 1960s and 1970s.

The team made two visits to the area. The first was made in April 1982 and the aim was :

1. To familiarize ourselves with the conditions of the project area.
2. To test the prepared questionnaires.
3. To locate and collect background information on the project area.
4. To visit some of the proposed sites.

During this visit 25 sites were visited and data from these sites were collected. During this visit the team obtained all lists of proposed sites. There were two lists: the first prepared by Rural Water Development Corporation in El Obeid and the second was the list prepared by the Forest Department showing their activities in hashab restocking. The idea behind incorporating the villages chosen for hashab restocking for investigation with regard to the possibility of water provision is

augment the acacia senegal restocking programme in the area and to integrate the two activities.

The second visit was made in May and June and lasted for 36 days. During this visit all proposed sites were visited and a village questionnaire was filled and observations regarding the environmental conditions were made. Detailed investigations were made in 20 villages where both village questionnaire and household questionnaires were filled. The total household heads interviewed reached 213.

Beside these activities, data was collected on pasture condition, vegetation types, density of vegetation cover as well as assessing the condition of the water source with regard to its need for rehabilitation or rectification.

It is hoped that the data collected on the physical and social resources will help us in suggesting control mechanisms and in designing environmental monitoring system. It is worth mentioning here that this is the first time when environmental considerations are taken into account when initiating development projects in the Sudan.

CHAPTER II.

GENERAL CHARACTERISTICS OF THE PROJECT AREA.

The Project Area lies between Latitudes 12°30' and 13°45' North and Longitudes 30°00' and 31°15' East with an approximate total area of 22,404 square kilometers. (Fig. 1). Administratively this area is divided into three districts namely :

1. Eastern Kordofan Region.
2. Central Region (Bederiya).
3. Northeastern Region (Dar Hamid).

According to 1973/74 Census the total population of these districts was found to be 428,720 persons of which 319,918 lives in Eastern Kordofan; 150.593 in Bederiya and 93 207 in Dar Hamid. It worth mentioning here that the Project Area do not cover the total area of the three districts. Thus the eastern part of East Kordofan including Wad Ashana Rural Council and Shirkeila Rural Council as well as the Northern part of Dar Hamid and the Western part of Bederiya district are excluded.

The 1973/74 Census show that population density not to be more than 13 persons per square kilometer in Eastern Kordofan and 10 persons in Bederiya and 9 in Dar Hamid. They live in villages and hamlets of different sizes. The

location and size of these settlements are influenced to a large extent by the availability and adequacy of water supplies. Thus villages with permanent and adequate water supplies are bigger in size and in most such villages the total number of households are found to exceed 300 while the total population exceed 1,500 persons (Tables 2.1 and 2.2). The tables reveal that most of the big sized villages are found in zones III, IV, V and VI, (Fig.1). Also it shows that about 20.5% of the villages surveyed have a population of more than 1,500 persons while 41% have a population of about 500.

Village size is also influenced by the resource potential of the hinterland, but the most important factor is water availability. Normally such big villages have more than one water source.

Main Tribes :

The Project Area is inhabited or visited by a number of tribal groups. They are both sedentary and nomadic tribes.

a) Sedentary tribes.

Gawama'a is the dominant sedentary tribe found to occupy most of Eastern Kordofan district especially the Central and Northern parts.

Bederiya occupies the central part around El Obeid town.

Dar Hamid (a name given to many tribes) occupy the most northern part of the Project Area around Bara town.

Shuweihat is found in the western and southwestern part.

Beside these dominant tribal groups there are many small tribes such as Hausa in Er Rahad area, Ghodiyat around Jebel Ed, Dair, Fellata around Barbur, Manasra in Umm Gezira and Tumam to the east of Kazgeil.

b) Nomadic Tribes.

Shenabla is found to be the main nomadic tribe roaming all over the Project Area staying between October and June and forming 49.5% of the nomadic tribes visiting the area. During the survey, Shenabla were found distributed in all physiographic zones.

Kawahla, Kebabish and Howaweer are new comers. They come to the Project Area because of drought and lack of pasture in their grazing grounds to the north. During the survey (April and May 1982) they were found around Bara and in zones IV and VII. These nomadic tribes own large number of camels and sheep.

Table 2.1.

Household Size of the Surveyed Villages according to Physiographic zones.

Zone	50		50-100		101-150		151-200		201-250		251-300		300 +		TOTAL	
	No. of Villages.	%	No. of Villages.	%	No. of Villages.	%	No. of Villages.	%	No. of Villages.	%	No. of Villages.	%	No. of Villages.	%	No. of Villages.	%
I	5	62.5	2	25.0	1	12.5									8	100
II			1	25.0			1	25.0					2	50	4	100
III					1	25.0			1	25.0	1	25.0	1	25.0	4	100
IV	4	33.3	6	50			1	8.3					1	8.3	12	100
V	1	6.6	12	80							1	6.6	1	6.6	15	100
VI	2	16.6			2	16.6	1	8.3			1	8.3	6	50.0	12	100
VII	5	45.5	5	45.5					1	9.0					11	100
VIII			1	25.0	1	25.0			2	50.0					4	100
Total	17	24.0	27	38.5	5	7.1	3	4.2	4	5.7	3	4.2	11	15.7	70	100

Table 2.2.

Population Size of the Villages Surveyed according to Physiographic Zones.

Zone No.	250 No. of Villages	%	251-500 No. of Villages	%	501-750 No. of Villages	%	751-1000 No. of Villages	%	1001-1250 No. of Villages	%	1251-1500 No. of Villages	%	1500 + No. of Villages	%	Total No. of Villages	%
I	1	12.5	6	75	--	--	1	12.5	--	--	--	--	--	--	8	100
II	--	--	1	25.0	--	--	1	25.0	--	--	--	--	2	50.0	4	100
III	--	--	--	--	--	--	--	--	--	--	1	25.0	3	75	4	100
IV	4	33.3	6	50	--	--	1	8.3	--	--	--	--	1	8.3	12	100
V	1	6.6	8	53.3	3	20.0	2	13.3	--	--	--	--	1	6.6	15	100
VI	1	8.3	1	8.3	1	8.3	-	--	1	8.3	1	8.3	7	58.3	12	100
VII	3	27.2	7	25.9	--	--	-	--	--	--	1	9.0	--	--	11	100
VIII	--	--	--	--	1	25.0	1	25.0	1	25.0	--	--	1	25.0	4	100
Total	10	13.6	30	41.0	6	8.2	7	9.5	2	2.7	3	4.1	15	20.5	70	100

Hawazma, is a cattle owning nomadic tribe used to spend the wet season in the south and southwestern parts of the Project Area to escape the mud and biting flies. found in the clay parts to the south. Table 2.3 shows the nomadic tribes that stay for some time in the area studied. It reveals that 49.5% of the nomadic tribes found during the survey were Shanabla while Kababish form 15.3% and Kawahla 7.2%. We did not find any Hawazma but a large number of villagers in Zones IV and V reported their presence during the rainy season.

Geology :

Two principal geological formations constitute most of the area of investigation. These are the precambrian Basement Complex and the tertiary - Quaternary Umm Ruwaba formation. There are minor occurrences of the Nawa formation as well.

The Basement Complex constitutes the southern part of the area. Its contact with the Umm Ruwaba Formation is roughly defined by the line El Hamra-El Gafeil-Umm Sot, from which point the contact swings to the north west. (See Fig. 2). Most of the basement is overlain by sand and/or thick residual clays. Basement outcrops occur as low hills such as the group of Jebels near Klein station

or the imposing Jebel Ed Dair south of Er Rahad. In Basement rocks, etc., there are numerous quartz ridges e.g. Ban Jadeed, Kurbaj, Much weathered rocks can be also examined in shallow wells dug along the numerous Khors (dry water courses) in the basement terrain.

The Basement Complex is a precambrian group of rocks usually subdivided into two categories : an older basement and the younger granites. The older basement underlies much of the basement terrain and consists of granite gneisses, older ulinremetagenine granites and migmatised granite gneisses and gneissos, accompanied by prominant quartz veins.

Without entering into the details of the older basement geology, it is sufficient to note that the part of the basement most favourable to ground water storage are the faults (utilized by Khors) especially those cutting through migmatised rocks.

Younger intrusive rocks occur in Jebel Ed Dair, Jebel Dambeir and J. El Tibna, all in the Gimeih Er Rahad area. The largest jebel in this group is Jebel Ed Dair which is a large granite mass which has influenced the patterns of settlement in the area through the water bearing pediment surrounding it. The Nawa Formation is a group of nearby flat lying beds of arcoses, greywakes,

Table 2.3.

Percentage of Nomadic Tribes Visiting the Sites Surveyed.

Zone No.	Shanabla %	Kawahla %	Kababish %	Howazma %	Others %	No Nomadic tribe Visit the Village %	Total %
I	61.5	7.6	7.6	--	23.0	--	100
II	50	--	16.6	16.6	--	16.6	100
III	60	--	20	--	20.0	--	100
IV	47.0	5.8	11.7	35.2	--	--	100
V	72.2	--	--	22.2	--	5.5	100
VI	100	--	--	--	--	--	100
VII	3.3	20	40.0	3.3	30.0	3.3	100
VIII	57.1	--	--	14.2	28.5	--	100
Total	49.5	7.2	15.3	11.7	13.5	2.7	100

micaceous mudstones and ferruginous mudstones. This formation is best known from a borehole drilled near Nawa Station where the formation is about 60 m. thick. The Nawa formation is partly preserved in downfaulted blocks and may be examined in some of the tributaries of Khor Abu Habil (Shaddad 1981).

Boreholes drilled into the Nawa formation in Nawa and Kazgeil have proved the formation to be capable of yielding a moderate water supply.

The Umm Ruwaba formation is largely a succession of coarse to fine sands and clays of riverian origin deposited over the greater part of the area under consideration. The Umm Ruwaba formation was deposited as a result of late tertiary movements, due to latter stages of the Afro-Arabian rift system. During this phase the Nuba Mountains block was raised while the surrounding areas to the north east, south east and west were gradually down warped. This down warping took place over a large area, resulting in the formation of broad shallow troughs filled with unconsolidated sediments. In our area and elsewhere more rapid down warping occurred along narrow grabens and this gave rise to deep trenches filled with great thicknesses of unconsolidated sediments. In the project area one

such trench was recognized by drilling and geophysical surveys (El Shafi pers. comm., Mitwalli. 1969, Strojexport 1970, Ali and Whitely, 1981). This trough was further outlined on the basis of borehole data, satellite photo-interpretation and field observations. The deep trench extends from a point southeast of El Ghabsha and extends in a WNW direction to Bara and El Kheiran area where it is truncated by a fault striking parallel to the present line of extension of the Kheiran oases. The Bara-Umm Ruwaba trench is of unequal depth being divided into three distinct parts : The Bara deep basin, the Umm Ruwaba deep basin and the intermediate basin of moderate depth (See Fig. 2). The actual depth of the outlined basins is not known precisely but the Bara basin is considered to be about 400 m. deep (Ali. Op.cit.), while the intervening part of the trench has a much less depth in comparison. Thus the Umm Ruwaba formation can be subdivided into three types : the thin Umm Ruwaba covering a broad area, the deep Umm Ruwaba in the Bara and Umm Ruwaba basins and the moderate Umm Ruwaba at shallower parts of the trench. It is generally conceded that the stratigraphy of the Umm Ruwaba formation is confused because of the highly variable nature of the riverian sediments. In this respect the Kheiran region

(El Bashiri etc.) is remarkable for the consistency of at least one bed· that of the quartz sands of low iron content (Shaddad, 1967). This bed is exposed erratically over an area of general north-south extent, of about 30 Km. long and 10-15 Km. wide. This leads us to postulate the existence of a lake of recent age extending over the Kheiran area and possibly Bara as well. The sediments of this lake are characterized by the alternation of white sands and sandy clays. The top most part of the section in the middle of the Kheiran lake is characterized by alternating pink sands and very light density clays with shell fragments, as well as a considerable admixture of diatomites accounting for the low density of the clays. Similar sediments are described from Bara (Shaddad 1967), as well as numerous interolume hollows and low lands all over central Kordofan (Hunting 1963). This clearly places the formation age as post wind blown Qoz.

Most of the basement surface is covered by thick residual clays of very wide occurrence. They underlie the wind blown sands and are exposed on wind shadows as far north as Umm Bader area. They are exposed by erosion in areas south of El Obeid and have been recorded in shallow wells dug on the crests of sand ridges overlying the

basement (so called longitudinal dunes). The Umm Ruwaba and most of the basement areas north of the Abu Habil Khor are covered by wind blown sand of variable thickness (up to 20-25 m.).

Tectonic Evolution of the Area :

Tertiary-quaternary tectonic movements have played an important role in the formation of the Umm Ruwaba sediments as well as the control of geomorphology and soil distribution in the area. The major trend in tectonic movements is the process of uplift of the Nuba Mountains block and the down warping of the Umm Ruwaba depression as a whole, and the formation of the deep Umm Ruwaba graben. These movements appear to have taken place during epoch of tectonic disturbance separated by epochs of relative tectonic stability. The movements have lead to unequal uplift of the Nuba Mountains block leading to the formation of more uplifted minor blocks such as the Rashad and Heiban blocks. Later on after the formation of the Qoz the Nuba block was faulted along the present course of Khor Abu Habil and this was followed by the rapid uplift of the areas north of the Kazgeil-Er Raha axis. This in turn lead to the rapid removal of the sand cover over the El Obeid block and the exposure of the underlying clay layer, especially in the more uplifted

smaller blocks such as the one between Khor El Abiad and Ban Jadeed. The numerous faults developing in the El Obeid block are utilized by Khors and are thus very important from the point of view of ground water localisation.

Repeated tectonic disturbances of the blocks north of the Umm Ruweba area have lead at times to opening and closing of wind corridors which in turn lead to the formation of zones of transverse dunes. Thus the eastern system of transverse dunes in the area was probably due to lowering of the region to the north and formation of a broad wind corridor, later suppressed. Hence the eastern system of transverse dunes can be viewed as older than the western system now being developed over the Kheiran. The peculiarities of the geology of the Umm Ruweba in the Kheiran areas can be explained as due to the development of a major river coming from the North at a time of humid climate. Following the establishment of the present desert conditions in the last 10,000 years or so the dry valley of the said river gave way to a wind corridor, responsible for the present desert encroachment over the Kheiran area.

Geomorphology and Soils :

The geomorphology of the project area is a product of interaction of pleistocene - Recent neotectonic movements

and climatic fluctiations. This is clearly seen from a consideration of the main geomophic units. The soil characteristics of each unit result from ancient and modern soil forming processes.

The main geomorphic units of the Project Area are considered here starting from the oldest (Fig. 3).

a) The ancient Umm Ruweba drainage system. One of the striking features of the area under consideration is the absence of major Khors draining the Nuba block in the direction of the Umm Ruweba graben. The mysterious disappearance of this major and extensive drainage system, can only be explained as a result of the widespread sand movement from the north and the subsequent formation of the Abu Habil channel which effectively sidetracked on coming water and sediments originating in the Nuba Mountains area. Thus the ancient drainage system was preserved as a system of sound ridges (30-25 m. high) alternating with broad troughs (up to 1000 m. wide) known by some authors as the longitudinal dunes (e.g. Hunting 1963, Pacheco & Dawood 1976).

The explanation provided by Hunting seems too ingeneous and does not fit the observed facts. According to those writers longitudinal dunes formed under the impact of alternating north and northeast winds thus

leading first to the formation of barchass and then the elongation of the barchass in a south easterly direction. (Warren 1970) who was not happy with the explanation preferred to refer to a "Zone of sand ridges" rather than longitudinal dunes. Warren also observed that sand ridges are often 25 to 30 m. high but show no preferred direction of assymetry of slope. They are usually gently curving or straight in plan and show regional swing groups rather than individual sinuosity. The distances between ridges vary from 600 to 1800 m. on average about 1650 m. Feild observations have shown that these sand ridges and their alternating troughs are underlain by basement rocks with a thick clay cover. The troughs serve as channels for running water during the particularly heavy rain season. On the other hand the troughs are lined by Boabab trees (Adansonia digitata) which usually occur along Khor beds. in this region.

Examination of the system of sand ridges in satellite imagery has shown that they end ubruptly against the margin of the Umm Ruwaba trench. It is noteworthy that the thin Umm Ruwaba sediments near the termination of the sand ridges. are coarser than usual. A similar explanation for longitudinal troughs and ridges was advanced by Bakheit (1982) for the area of NE Darfur and NW Kordofan.

Since drainage within the Umm Ruwaba hinterland is largely controlled by faulting it follows that the system of longitudinal troughs can be an important source for shallow lying ground water. The soil characteristics[1/] of the sand ridge and hollow areas are governed by two factors :-

i) In the sand ridges it appears that a slight concentration of the clayee fraction occurs at the lower ridge slopes. Hence the ridge crests and slope soils are mainly reddish yellow sands of weakly fine to subangular blocky structure grading into structureless massive sands of neutral reaction (PH 7.0-6.6). Sometimes sharp changes of PH (to about 5.3) are noted in lower ridge slopes and attributed to more ancient soils being covered by fresh sand.

On the whole these sands are low in nitrogen and available phosphorus and have moderate potassium supply. Exchangeable calcium is very low or absent. Low ridge slope soils were found to have better moisture regime than crests and upper slopes. They have four times available moisture (3.0%) than the crests and water movement is less rapid. For these reasons cultivation is mainly concentrated on lower ridge slopes.

1/ All soil data re extracted from Hunting, 1963.

Interridge hollows are often occupied by lacustrine deposits intermixed with ferruginous clays brought down from the sand ridges. A typical interridge hollow shows soil consisting of an upper sandy layer followed below by layers of grey sandy loam to sandy clay loam. The reaction of the soil is strongly alkaline. Shell fragment are common. Phosphorus and nitrogen are usually low while potassium is moderate. Exchangeable Na very low and the soils are usually none saline easy to cultivate and yield good crops of Penisettum, Sorghum and Sesame. In places the clay content may be great and under prevailing climatic conditions it cannot be utilized for cultivation.

b) Sand Sheet over Umm Ruweba Sediments :

This geomorphic unit may be further subdivided into transverse dunes and dune complexes without preferred orientation.

i) Transverse dunes occur in two main fields : a large triangular field north of Tayara and east of Bara covering an area of 1300 sq.Km. and a narrow elongate field west of Bara trending S-N from Ashaf El Bashiri villages to Sharashar in the north. The area of this field is approximately 500 Km. These shall be considered here in brief.

ii) The main field is apparently the older of the two. Sand movement within this field is practically arrested by the growth of vegetation. In the South near El Tayara where the dune field tapers off, the topographic contrast between the dune crests and valley bottoms is usually in the range of 10 m. At the valley bottom the sand is slightly more cohesive than at the slope or crest. There is slight difference between dune crests (natural to slightly acid 7-6.2) whereas at the bottom it is neutral throughout the soil profile. There are differences emphasized in other ways. For instance organic carbon content, total nitrogen available potassium and exchangeable calcium, all decrease from valley bottom to dune crests. Though the soil is excessively drained the available water for plant growth in the hollows is slightly more than in crests a fact emphasized by plant distribution and patterns of cultivation.

In that part of the transverse dune field lying between Bara and Umm Dam the dune morphology is more contrasting and the hight of crests above hollows varies from 10 to 20 m.

The difference in soil condition between crests and slopes is illustrated by soil structure ranging from single grain to structureless massive. PH values

vary also from neutral to moderately alkaline.

Dune hollows in this area are often the site of development of strongly alkaline loamy soils developing on a substratum of locustrive deposits.

Both nitrogen and phosphorus are low and pottassium moderate in all soils. Phosphorus however is slightly greater in the hollows, a fact which, together with the increase in water retention, encourage the greater development of vegetation in the hollows.

The dune field west of Bara is the more recent and the more unstable. The field is a good example of sand encroachment at present conditions. This is clearly seen in setellite photographs (Abbas Doka, 1980). Whereas the sand sheet is continuous for a long distance at the source, it is still developing in the Kheiran region where large gaps still exist in the sand sheet, through which both the layer of white quartz sands and fragments of the original depression filled with locustrine deposits (The Kheiran proper) can be clearly seen. Transverse dunes of low amplitude are developed over the quartz and of El Kheiran whereas transverse dunes of more contrasting topography are developed to the north over the red sand sheet. The trend of the sand are east west. No data on dune topography exist. Barchans are a common feature of this dune field.

Dune soils examined near El Bashiri were found to co sist of structureless single grain loose sand on dune crests with strongly to moderate alkaline reaction (8.7-8.2) while on dune hollows the sand is weak, fine granular subangular and hard with a neutral alkaline reaction. The sand has very uniform grain size on the crests and very permeable. Chemical data for dune crest soils show very little organic carbon no nitrogen, low phosphorus and rather low potassium. Both exchangeable Ca and magnesium are lower than expected for sands in the Kordofan region.

iii) Dune complex. The rest of the sand sheet in the area is a surface consisting of dunes of random orientation probably due to interference of winds of variable direction. Unfortunately no clear data on the soils of this type exist though they may generally be comparable to those of sand dunes of the same type located outside the project area. These are weak fine granular sands with mild alkaline to neutral reaction on crests and mild alkaline reaction on slopes. The soils of hollows are developed on a mixed substrate of sand and lacustrine clays. Chemical properties show low total nitrogen and available phosphorus. Potassium value are in the usual range for such sands.

c) The El Obeid emerging pediplain. This tectonically activated block can be roughly delimited by the polygon Er Rahad-El Gefeil-El Kharta-Khor Kazgeil. The raising of the block is accomplished by hinging around this Khor. The tectonic movement took place by utilizing numerous faults possibly of much older age. As a result of this movement along these faults, probably many timesin post geologic epochs they were intensly fractured. They were used as natural courses for Khors draining the imergent block, a fact of great significance in relation to water supply.

One important result of the uplifting of the El Obeid block is the active erosion of the wind blown sand and often the exposure of underlying plain clays; the so called cotton soil. As a result the region is covered by a mosaic of soil types from sands to loamy sands and clays to black clays. The depth of erosion being directly related to the extent of uplifting of the different blocks of which the Megablock is composed. This often leads to the jusctaposition of completely different soil types on opposite sides of Khors.

The truncation of the sand ridges and trough complex resulted in the production of a broad zone of discharge of ground water extending from Er Rahad to El Gefeil and

Khor Taggat (See Fig. 3). This zone is characterized by the presence of numerous water ponds (Rahads) especially during and just after the rains. This is a populer area among the nomads. Soil types covering El Obeid block can be summed up as follows :-

The clays, the loomy clay sands and the sandy soils. They represent arbitrary levels of a continuous spectrum of erosion. The three types are admirably expressed by distinct plant associations. The clays represent the lowest level of erosion in the area. They occur over a wide central area starting from Khor Kazgail to Jebel Kordfan (See Fig. 3). They are characterized by moderate to strong alkaline reaction exchangeable sodium percentage is 5 and the soluble salts are sodium bicarbonate and sodium chloride. The soil is low in phosphorous and nitrogen. The available potassium value is moderately high.

The sandy clay loams are soils transitional from the full section of superficial deposits (wind blown sand on clay) to that of the extremely reduced section (clay). Thus they vary from a relatively thick sand layer to thin reddish clayee losm to loomy clay resting on the block clays.

A section of this type of soil was examined inside Timeid village in an artificial pit. The first 60cm. of the section consisted of fine brown red loamy sand fallowed by a transitional zone 60cm. wide, consisting of sandy loam grading into greenish grey plastic clays. Here the sand contains numerous inclusions of clay and vice versa, a situation that can be the result of repeated interaction between the periodically swelling calsys and a thin overlying sandy loam layer. It is our opinion that the sandy loam represents the fine material deposited in advance of wind blown sand proper. Pedologic characteristics of this soil are not much different from the clays with the difference in the more sandy nature of the top brown horizon.

Climate :

The project area lies roughly between the 300 and 500 mm. isohyets. According to Van der Kevie (1976) the area could be subdivided into three climatic zones (Fig.4) as follows :-

Al.1 - Arid warm winter.

Al.2 - Arid cool winter.

Sl.1 - Semi-Arid warm winter.

A. Arid climates : temperatures are rather high. Minimum temperatures in the hottest month (May) is 40-42°C. "There is no month in which the average rainfall exceeds potential evapotranspiration (humid month), though there is at least one month in which the rainfall exceeds 50% of the potential evapotranspiration (intermediate month). The average rainfall ranges between 225 and 400 mm. (Van der Kevie, Op.cit.).

A1.1. Arid Climate with summer rains and warm winter. The rain falls mainly in the months of June-August. Mean minimum temperature of the coldest month (January) is 13-17°C.

A1.2. Similar to A1.1 but mean minimum temperature in the coldest month (January) is 8-13°C.

S. Semi-arid Climates : Temperatures are high though slightly lower than in the arid and desert climates. Maximum temperatures of the hottest month (April or May) are 35-40°C. The average annual rainfall is less than 44% of the annual evapotranspiration. There is at least one "humid month" where average rainfall exceeds potential evapotranspiration. There are one or two intermediate months and the growing season (humid plus intermediate months) ranges from two to four months. Relative humidity usually low throughout the year (20-40%) rises to 70% durin the rainy season.

Sl.1. Semi-arid climate with summer rains and warm winter :

Average annual rainfall is 400-750 mm., (within project area - 400-500 mm.); the rainfall mainly in the months May-September. Maximum temperatures of the hottest month (April or May) are 39-40°C. whilest the mean minimum temperatures of the coldest month (January) are 13°-17°C.

Vegetation :

Vegetation in the project area is a function of rainfall and soil type. Thus within a given rainfall belt there are distinct plant associations for clay and sandy soils.

On the other hand the region has been settled for centuries, with extensive agricultural and grazing practices. These human activities plus economic pressures starting from the early nineteenth century, in favour of Acacia senegal the gum arabic tree have left a pattern of vegetation associations that is obvious greatly modified by man. Hence the plant associations mentioned below can be correctly regarded as a climax of interaction between man and his environment.

In compiling this account we relied heavily on the survey conducted by Hunting Technical Service Ltd. (1963) as well as our personal observations.

The major plant associations in the region are classified as follows (Fig.5) :-

I - Semi-desert grass land on sand subformation, this includes :

1 - Aristida-Pallida - Leptadenia Pyroteehnica association and a variety of this association (Iu) in the shifting dunes of the Kheiran area.

II - Acacia Senegal Savannah or sand subformation, this includes :

IIa - Acacia tortilis - Leptadenis pyrotechnica association.

IIb - Acacia Senegal - Leptadenia association.

IIc - Acacia Senegal combretum Cordufanum association.

III.- Savannah thorn Scrub subformation includes :

IIIa - Acacia mellifera association.

IIIb - Acacia nubica association.

I - Savannah grassland on sand subformation. This subformation covers most of the northern part of the area, it is subdivided into two associations on the basis of the habitat. These are :-

Ia - Aristida pallida - Leptolenia pyrotechnica

This association occurs on sand sheets and stabilized low dune complex. The sand is well drained and the dune hollows are not markedly different from dune crests in relation to moisture content (very low). The dominant species of plant is the grass Aristida pallida locally Cymbopogon gigamteous may be prominent. In the southern part of the area Leptadenia pyrotectnnica usually predominates. Other species present include Aristida mutobilis, Eragostis tremula with common herbs such as Tephrosia Obseordata, Chascanum Marubiifolium and Chrozophora brochiana.

These are rare and occur usually near settlements and include Acacia Tortilis, Acacia albida and Balanites aegyptiaca.

The association is apparently a secondary grassland derived through continuous grazing and overcultivation.

Iu : Panicum turgidum : This association occurs in the Kheiran area of transverse dunes west of Bara. Here most of the dunes are being created by the strong N-S winds and are undergoing stabilisation. A complex pattern of colonisation is observed wherein Panicum turgidum and Leplodinia Pyratecnnica occupy the dune

crests and areas of stable sand, while Andropogon gaganus and tephrosia obcordatoi occupy the middle slopes of dunes. The lower dune slopes are occupied by Cenchras bifloria and Aristida pallida. Tephrosia Lipinufolia occurs both on dune slopes and the sandy hollows.

In the same region low lying areas not covered yet by the encoraching sand and having soil based on lacustrine sediments. These hollows are dominated by Acacia Tortilis with some acacia albida A. nubica and A. Senegal. Balanites aegyptiacum and Ziziphus Spinochristi are frequent.

II. Acacia Senegal savannah on sand subformation occurs on sand sheets and sand ridges between 250-300 mm. and the 400 mm. isohyets. It includes three principal associations. These are :-

IIa - Acacia tortilis subsp. raddiana - Leptodenia pyrotechuica. This association covers the north part of the domain of acacia senegal savannah.

A. tortilis is the dominant tree species. It is associated with rare representatives of acacia senegal and acacia albida. Balanites aegyptiacum is frequently encountered while maerua crassifolia may be badly dominant. Leptadenia pyrotechnica is always present on dune crests.

IIb - Acacia senegal association comprises different societies under different conditions e.g. Acacia senegal - Leptodina, A. Senegal - halanites.

In the sand sheets and low dune complexes south of Bara and Um Dam deliberate encouragement of the economically valuable Acacia senegal has led to formation of societies where A. Senegal is prominant or dominant often to the exclusion of other tree species pure or nearly pure societies of A. Senegal are found and their distribution follows that of cultivation and settlement.

In typical areas of heavy cultivation the A. Senegal is usually found on dune crests while the hollows are colonized by Ziziphus spinochristi which grow on mounds of sand accumulating along fences (Zaribas).

Other trees in the association include A. Salbida sometimes balanites. The grass cover is often sparse and usually dominated by Aristida pallida. Other grasses include Cenchrus lifloris, Eragrostis tremula.

IIc - Acacia senegal - combratum cordofanum. This association occurs on the eastern part of the sand ridge areas, also on sand sheets north of Umm Ruwaba where leptadenis is notable. A more humid variety occurs in sand sheets in the Kazgeil area with Delbergia melanoxylon being codominant.

The sand ridge region is dominated by characteristic plant zonation. Here Combretum alone or with acacia senegal dominate the ridge crests, while villages in the same position are surrounded by areas of barren soil. Macrus crassifolia, Combritum aculeatum and Boscia senegalensis may also occur. The lower slopes used for cultivation are dominated by patches of acacia senegal. In the interridge hollows with clay soil Acacia nubica and/or acacia mellifera are the dominant trees. In the axes of these hollows Adansonia digitata is often encountered.

III. Thorn scrub subformation include two associations :

a - Acacia melifera association occuring on areas with sandy clay loams where the red clay loams overlie old black clays of the basement plains. Acacia mellifera dominates this community often forming dense thickets especially around the shallow seasonal rain pools. Acacia nubica, commiphora africana and loseicn senegalensis prefer the drier sites, in association with Acacia mellifera.

b - Acacia nubica occurs principally on the dark clays exposed by erosion of the sand sheet. They may be accompanied by Boscia senegolensis.

IV. The Riparian Association : The composition of this association is influenced directly by the moisture regime of the Khor course. In upper parts of first order streams the dominant tree species is Adonsonia digitata which is usually very old and rather shrivelled. In the lower half of the 1st. order streams where the Khor acquires a recognisable flood plain the trees are Adansonia, Acacia albida often very large, combretum cordufanum and where standing water is found A. nilotica. In 2nd. and higher order streams where flood plains are wide (up to 2.5 Km.) acacia mellifera occurs with notable adansonia large A. albida, Combretum balanites aegyptiacum, A. nilotica as well as Albizia amera var sericocephala: Ziziphus and Tamaeindus indica.

Social Services in the Project Area :

It is quite noticeable that the availability of services is correlated with the availability of water supplies. In fact water provision attracts services and regarded as the most important single factor which stimulate social and economic development. In fact, the whole strategy for rural development in Western Sudan was based on the belief that water provision enables villages to grow and develop central functions and may become growth centres when the necessary infrastructure for growth are provided.

Studies carried in East Kordofan Region (Part of the Project Area)(Y. A. Mohamed 1981) showed that the provision of improved rural water supplies attracted more people and their animals to the source area. It was found in some villages of the area that more than 34% of the respondents migrated immediately after water provision. The extent of that migration is shown in Table 2.4.

Table 2.4.

The Effect of Water Provision on Total Number of Households and Population of some Villages in E. Kordofan.

Name of Village	No. of House-hold before water.	No. of House-hold after water.	Total No. of Population before water.	Total No. of Population after water.	% Change.
Kadada	0	454	0	2500	100%
Rokab	162	194	859	2100	145.6%
Medesis	31	47	164	250	52.4%

Source: Y. A. Mohamed et.al, 1981 "The Impact of Improved Rural Water Supplies on the Environment: The case of East Kordofan District", Unpublished Report.

Thus it is clear that settlements with better water sources grow in size. Also the amount and nature of water supply influenced the extension of minor services. After water provision, schools and dispensaries were established in many villages. The Number of services found in a

village are strongly correlated with the age of the water source. Thus it is found that the number of services decline from the oldest to the youngest water point.

Personal Characteristics of the Sampled Population :

In the Project Area, and as stated earlier three types of investigations were carried. In total more than 70 villages and proposed sites were investigated. In all these sites a village questionnaire was administered. In this questionnaire, general information concerning the village was collected and collective view of the villagers about the water supply they get was assessed.

To get detailed information about water consumption and water use habbits, a household questionnaire was filled in 21 villages and a total of 213 persons were interviewed. The results of this questionnaire forms the basis of our analysis on matters concerning water demand and supply and water collection and use.

In some selected villages with wateryards an observation sheet was filled to get information on numbers of people and animals using the wateryard as well as a detailed record of what happens in the wateryard from opening till it was closed.

Based on the household questionnaire it is possible to draw some conclusions about the personal characteristics of the sampled population.

In the selection of the sampled households an attempt was made to achieve some representation of the different physiographic zones. Thus 25.8% of the total sampled population was selected from zone IV while only 7.00% from zone I. This reflects the density of settlements in each zone. It is clear that zone IV is relatively densely populated and with more water sources.

The sampled households heads are of different age groups (Table 2.5) and all of them are married (Table 2.6) and 60% are illiterate. Table 2.7 shows that only 16.4% attended primary school.

The average family size differs from one village to the other but most of the household heads (41.8%) have between 1-5 children and 34.7% have between 6-9 children (Table 2.8).

The different occupations found in the Project Area are well represented in our sample (Table 2.9). The table reveals that about 92% of the household heads consider farming as their main occupation. This result means that they combine crop farming with some form of animal rearing. Those respondents who stated that their

main occupation is animal keeping form only 0.5% of the sampled population.

During the dry season most respondents practice jobs other than farming (Table 2.10). The table shows that the most important secondary job in the Project Area is gum collection which accounts for 46.4%, followed by animal keeping.

With regard to water supply; it is found that most of the respondents are not very close to the source. It is found that 35.5% live at a distance more than 2 Km. from the source (Table 2.11), and only 18.5% live at a distance less than ½ a kilometer. This feature affect the amount of water collected, number of trips, mode of transport and the type of water collectors. All these will have a major influence on the amount of water consumed at the household level.

Table 2.5.

Age of Household Heads According to Zones.

Years / Zones	Less than 20		20-29		30-39		40-49		50-59		60 +		Do not Know		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	--	--	2	13.3	2	13.3	8	53.3	2	13.3	1	6.7	--	--	15	7.0
II	--	--	5	16.7	4	13.3	8	26.7	4	13.3	9	30.0	--	--	30	14.00
III	--	--	7	24.1	10	34.5	5	17.2	6	20.7	1	3.4	--	--	29	13.0
IV	--	--	3	5.5	12	21.8	20	36.4	14	25.5	6	10.9	--	--	55	25.8
V	--	--	9	29.0	9	29.0	9	29.0	3	9.7	1	3.2	--	--	31	14.5
VI	--	--	8	25.0	9	28.1	8	25.0	3	9.4	4	12.5	--	--	32	15.0
VII	--	--	2	9.5	9	42.9	3	14.3	2	9.5	5	23.8	--	--	21	9.8
Total	--	--	36	16.9	55	25.8	61	28.6	34	16.0	27	12.7	--	--	213	100

Table 2.6.

Age of Wife of the Household Head.

Years / Zones	Less 15		15-24		25.34		35-44		45-54		55 +		Do'nt know		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	--	--	3	20	4	26.7	8	53.3	--	--	--	--	--	--	15	100
II	--	--	4	13.3	10	33.3	7	23.3	7	23.3	--	--	2	6.7	30	100
III	1	3.4	5	17.2	11	37.9	6	20.7	3	10.3	--	--	3	10.3	29	100
IV	--	--	7	12.7	19	34.5	22	40	5	9.1	1	1.8	1	1.8	55	100
V	--	--	10	32.3	12	38.7	7	22.6	2	6.5	--	--	--	--	31	100
VI	--	--	11	34.4	12	37.5	6	18.8	3	9.4	--	--	--	--	32	100
VII	--	--	6	28.6	3	14.3	8	38.1	3	14.3	1	4.8	--	--	21	100
Total	1	0.5	46	21.6	71	33.3	64	30.0	23	10.8	2	0.9	6	2.8	213	100

Table 2.7.

Education Level of Household Heads.

Ed.Level / Zone	Illiterate.		Reads and writes.		Khalwa		Primary		Intermediate.		Secondary		Post Secondary		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	7	46.7	--	--	6	40	1	6.7	--	--	1	6.7	--	--	15	100
II	22	73.3	2	6.7	4	13.3	1	3.3	1	3.3	--	--	--	--	30	100
III	25	86.2	1	3.4	3	10.3	-	--	--	--	--	--	--	--	29	100
IV	27	49.1	3	5.5	11	20	14	25.5	--	--	--	--	--	--	55	100
V	14	45.2	4	12.9	4	12.9	8	25.8	1	3.2	--	--	--	--	31	100
VI	23	71.9	2	6.25	2	6.25	5	15.6	--	--	--	--	--	--	32	100
VII	11	52.4	2	9.5	2	9.5	6	28.6	--	--	--	--	--	--	21	100
Total	129	60.6	14	6.6	32	15.0	35	16.4	2	0.9	1	0.5	--	--	213	100

Table 2.8.

Number of Children.

No. of Child. / Zones.	No Children		1-5		6-9		10 +		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
I	--	--	4	26.7	9	60.0	2	13.3	15	100
II	3	10.0	12	40.0	11	36.7	4	13.3	30	100
III	3	10.3	15	51.7	10	34.5	1	3.4	29	100
IV	--	--	17	30.9	17	30.9	21	38.2	55	100
V	--	--	13	41.9	10	32.3	8	26.8	31	100
VI	3	9.4	16	50.0	11	34.4	2	6.3	32	100
VII	2	9.5	12	57.1	6	28.6	1	4.8	21	100
Total	11	5.2	89	41.8	74	34.7	39	18.3	213	100

Table 2.9. Main Occupation of the Household Head.

Occupation / Zones.	Farmer		Merchant		Animal Owner		Gum Collector.		Govet. Official		Others		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	13	86.7	--	--	--	--	--	--	1	6.7	1	6.7	15	100
II	30	100	--	--	--	--	--	--	--	--	--	--	30	100
III	29	100	--	--	--	--	--	--	--	--	--	--	29	100
IV	51	92.7	1	1.8	--	--	--	--	2	3.6	1	1.8	55	100
V	27	87.1	2	6.5	1	3.2	--	--	1	3.2	--	--	31	100
VI	27	84.4	1	3.1	--	--	--	--	1	3.1	3	9.4	32	100
VII	19	90.5	1	4.8	--	--	--	--	--	--	1	4.8	21	100
Total	196	92.0	5	2.3	1	0.5	--	--	2	2.3	6	2.8	213	100

Table 2.10.

Secondary Occupation of the Household Head.

Sec. Occupation / Zones	Farmer No.	Farmer %	Merchant No.	Merchant %	Animal Owner No.	Animal Owner %	Govet. Official No.	Govet. Official %	Tailor No.	Tailor %	Carpenter No.	Carpenter %	Black Smith No.	Black Smith %	Charcoal Firewood No.	Charcoal Firewood %	Gum Collector No.	Gum Collector %	Shepard No.	Shepard %	Others No.	Others %	Total No.	Total %
I	1	4.5	2	9.1	2	9.1	1	4.5	-	-	-	-	-	-	5	22.7	9	40.9	-	-	2	9.1	22	100
II	--	--	6	18.1	4	12.1	-	-	1	3.0	-	-	-	-	5	15.2	15	45.5	-	-	2	6.1	33	100
III	--	--	7	20	4	11.4	1	2.9	-	-	-	-	-	-	4	11.4	16	45.7	-	-	3	8.6	35	100
IV	5	8.5	6	10.2	5	8.5	1	1.7	1	1.7	-	-	-	-	-	-	36	61.0	-	-	5	8.5	59	100
V	3	8.3	4	11.11	2	5.6	-	-	-	-	-	-	-	-	3	8.3	21	58.3	-	-	3	8.3	36	100
VI	4	13.3	2	6.7	9	30	-	-	1	3.3	-	-	-	-	4	13.3	4	13.3	-	-	6	20	30	100
VII	2	11.11	2	11.11	6	33.3	-	-	-	-	-	-	-	-	-	-	7	38.9	-	-	1.5.6		18	100
Total	15	6.4	29	12.4	32	13.7	3	1.3	3	1.3	-	-	-	-	21	9.0	108	46.4	-	-	22	9.4	233 (*)	100

(*) Some household heads have more than one secondary occupation.

Table 2.11.

Distance of House from Water Source.

Zones / Km	Less than ½		½-1		1.1-1.5		1.6-2.0		More than 2		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	--	--	3	20.0	1	6.7	--	--	11	73.3	15	100
II	4	14.3	2	7.1	-	--	2	7.1	20	71.4	28	100
III	6	20.7	8	27.6	-	--	--	--	15	51.7	29	100
IV	12	21.8	18	32.7	16	29.1	1	1.8	8	14.5	55	100
V	2	6.5	7	22.6	5	16.1	3	9.7	14	45.2	31	100
VI	1	3.1	7	21.9	5	15.6	12	37.5	7	21.9	32	100
VII	14	66.7	6	28.6	1	4.8	--	--	--	--	21	100
Total	39	18.5	51	24.2	28	13.3	18	8.5	75	35.5	211	100

CHAPTER III

SOURCES OF WATER SUPPLY IN RELATION TO GEOLOGY

Water in the project area is collected both by direct storage or running surface water in Hafirs (artificial reservoirs) and by tapping underground water sources. No system of permanent rivers is found any where in the region.

Surface water :

The presence of dry water courses(Khors) is confined to the El Obeid block (see Fig 5). These Khors eventually join with those coming from the Nuba Mountains, and, near El Rahad. They give rise to a single channel of Khor Abu Habil which extends down to Wad Ashana where it ends in a great delta extending down to the White Nile. The El Obeid branch of Abu Habil system joins the latter near El Rahad where it is dammed up at present, giving rise to a large lake with a surface area of 6.25 sq.Km. and a storage capacity of about 3-5 million cubic meters. The water of the Khor system are utilized by 21 Hafirs and dams (see Table p.203), with a total capacity of 6 million cubic meters. Thus the total storage capacity is about 12 million cubic meters half of which is stored at El Rahad, where it does not completely utilized. There is a pipe line project to bring water to El Obeid town for domestic use from Er Rahad lake. It is our estimate that the total

stored water represents less than half the available water in the stream courses.

Ground Water :

Ground water supplies the bulk of water need of the population of the project area. Those living to the south of the Umm Ruwaba-Er Rahad-El Obeid railways line (including El Obeid) depend only marginally on ground water, which is tapped by wells in villages too small to warrant their own Hafir. On the other hand people living north of this line (with the exception of Er Rahad and Simeih) depend exclusively on ground water sources for their needs. They represent about half the population of Northern Kordofan Province. In view of this it is curious that this important natural resource has never been adequately assessed. Knowledge of the geology and hydrogeologic parametes of the major water source, the Umm Ruwaba sediments is extremely limited.

Prior to 1967 very little drilling for water was carried out and that is mainly in Umm Ruwaba town and adjoining railway stations. The grandiose scheme launched by the Rural Water Development Corporation (RWDC) for tapping of water resources, resulted in

drilling of about 200 boreholes in Dar Hamid (Bara) and Eastern Kordofan (Umm Ruwaba) rural districts alone. This great effort was directed towards the solution of the immediate needs of the population and for various reasons the vital task of tabulating and analysing the borehole data was not accomplished. The variety of these data, collected by contracting companies in a hurry and without adequate supervision is at best questionable. Vital information on the Umm Ruwaba, such as the thickness of sediments is lacking or incomplete. On the other hand no long term observational data are available. It is therefore difficult to predict the future availability of ground water in this particular area.

There is practically no unified body of knowledge concerning the conditions of localisation of water in the basement. There used to be a rule of thumb stating that you can find water in the Umm Ruwaba and Nubian sandstone groups but that the basement is hopeless. The time has come for a general theory on the pattern of localisation of ground water in the basement. This is particularly so because most of mechanised agriculture, on which the Sudan's vital food supplies are increasingly dependent, is located in the "waterless" basement areas.

In the following sections we shall attempt to ac characterize the availability of ground water in the various geological formations in the project area.

The Basement Complex is generally a compact formation incapable of storing ground water except in zones of intensive fracture. These zones are utilised by running water and the result is a narrow linear zone of ground water storage. Adequate water supply is ensured in the lower parts of order streams as well as all steams of higher order. An interesting example of water in the basement is Khor El Abiad south of El Obeid. The north half of the Khor is characterised by a narrow sand filled channel with no flood plain. This part did not yield appreciable water and is not being utilised for this purpose. The lower half of the Khor is a relatively broad flood plain up to 1 m. wide and filled with alluvial clays some 8 meters thick. The meandering channel is very narrow - less than five meters and is characterized by the presence of sand and steep banks. About 20 boreholes were drilled into the flood plains and they were mostly successful. The average depth of boreholes is 50-60 m. Adequate water was struck in these boreholes with a yield of 600-1400 gallons/h.(gph).

Experience has shown that the best water supply is con confined to the flood plain. The variation in water supply is supposed to be related to the method of drilling. Rotary drilling was found to be counterproductive si since the pressure of drilling muds is often enough to plug the aquifer. For this reason purcussion drilling is preferred. The latter method has the added advantage of allowing wider boreholes to be drilled, a fact which contributes towards higher yield. Salinity is moderate and total dissolved solids (TDS) do not exceed 300-700 ppm. which is considered suitable for human consumption and agricultural purposes.

Besides Khor El Abiad we examined shallow wells in the Khor Sikeiran and Kazgeil area (Et Timend, Sweilim Ghasiba etc.) water was found generally at a level of 24 to 30 m. No estimate of production from shallow wells is available.

The Nawa Formation : This rather limited formation is considered of marginal importance in relation to ground water. Boreholes drilled in Nawa rocks (Nawa Kazgeil, Alloba, Giebat) usually encountered water at depths of 75-300 m. and gave yields not exceeding 1500 gph. An unexplored possibility is the occurrence of

supplies of water in small fragments of the formation preserved in faults marked by Khors.

The chemical quality of water in the Nawa formation is satisfactory despite the relatively high ca Mg iron content.

The Umm Ruwaba formation is the most important source of water supply in the area. The geology of th the formation was partly disclosed by the numerous wells and boreholes (Regwa 1969) as well as some geophysical and hydrogeological investigations, (Mitwalli 1969 Strojexport 1977, Salama 1977, Ali & Whitely 1981). During the field investigation and analytic work related to this project, it was possible to make a syntheses of existing data, which is expanded below.

The Umm Ruwaba depression covers a large part of northern Kordofan. From geophysical and borehole data it is possible to recognize a wide shallow depression and a long deep graben extending from Bara to Umm Ruwaba. The graben can be further subdivided into separate basins according to thickness of sediments, and other factors (See Fig.2).

We shall now review the characteristics of each separate unit :

The shallow depression can be subdivided into two parts a southern and a northern parts according to their positions relative to the groben.

The southern part of the depression is a narrow strip zone 2-3 Km. wide extending from Khor Abu Habil at a point near Abu Hamra and extends along the south edge of the graben in a northwesterly direction past Um Sot and further to the west. Boreholes were drilled into this part of the formation at Kuanamousa, Um Sireiha Bogadi, Abu Saad and Um Higleig. Judging from the section of Um Sireiha Bagadi the Umm Ruwaba formation is underlain in places by Nubian rocks often of a considerable thickness (up to 120 m.thick). The Umm Ruwaba sediments show rapid changes of lithology with alternating sands and clays. The latter usually dominate the section. The thickness of sediments is more than 255 m. but the basement may be encountered at shallower depths (200 m. in case of Um Sireiha Bagadi.)

The yield is highly variable ranging from 500-800 gph. with frequent failures. The static water level

(SWL) is about 70-100m. Salinity is generally high being about 1200-1500 ppm. which is on the whole acceptable for human consumption. This high salinity is attributed to the high clay content. It is worth-mentioning here that salinity in water of Umm Ruwaba sediments increases with depth and with clay content of the section (Ali & Whitely) 1981).

The Umm Ruwaba depression north of the graben is a wide area covering more than 6000 sq.Km. along the project area (See Fig.2). The geology of the formation is very complex here and is complicated by the presence of numerous faults (such as that along Um Balagei) and possibly minor grabens. We were able to distinguish two zones one north of the Umm Ruwaba basin (Zone 1) and the other north of the Bara basin (Zone 2). (Fig.2).

Zone 1 is apparently a linear zone of approximately north south extent. It includes Umm Burma, Simein, Misheilikh Wad Sabil, Umm darmi and Tafantara. These wells are characterized by substantial water characteristics probably due to similarity of geologic conditions (secondary graben?). They all give moderate yield around 900-1500 gph. salinity is moderate with TDS

600-800 ppm.

Wells located on both sides of this presumed structure of Um Gannas and Er Roga yassin are noted for the many failed boreholes and low yield in "successful" wells usually about 500 gph.

Zone 2 includes boreholes Zeidan Magrour, Ez Zerieba, Wad Malli and Um Recka. The Umm Ruwaba sediments consist of medium to fine sands and some clay beds. The thickness not exceeding 30 m. Most boreholes penetrated nubian rocks with thickness of up to 33 m. The basement rocks were penetrated at depths ranging from 90 to 200 m. Judging from the unreliable well logs supplied by REGWA the Umm Ruwaba cover is not continuous and in places the wind blown sand rests directly over Nubian rocks.

Drilling results are inconsistent with dry and successful boreholes in closely located sites. The yield in successful boreholes is usually moderate, about 700 to 1200 gph. Salinity is moderate being about 450-500 ppm. In Zaida where the Nubian is the only sedimentary formation the salinity shoots up to 1500 ppm.

The Umm Ruwaba graben : the north western part of the Umm Ruwaba graben (what we call here the Bara and Tayara basins) was studied by Ali & Whitely who estimated the thickness of sediments at the deepest part to be 1400 m. The thickness of the Umm Ruwaba basin at the south east end of the graben is not known. From the geophysical evidence it is obvious that the graben is bound by steep inward dipping gravity faults. We have postulated a number of faults cutting across the graben. This is based on analysis of the significance of geomorphic features such as Khor Abu Habil and the Qoz El Hajiz (See Fig5). Accordingly the graben is subdivided into 4 units which would be discussed separately.

The Bara Basin is an elongate feature of approximately east west trend. At the deepest part the basin is 1400 m. deep and is filled with loose unconsolidated sands clays and gravels. The start - igraphy of the basin is not yet clear. The sediments are characterized by marked facies changes which make correlation difficult. A number of boreholes were drilled, many of them at Bara other in Mileiha, Um Sot, Um Busha Um Gerif, Khursi Um Tayur, Asida and

El Rokab. An important feature of some of these boreholes e.g. Bara, Khursi, Um Gerif, is the presence of a clayee horizon not far below the Qoz sands. This conditions the presence of two water bearing horizons. The upper and poorer aquifer is that of perched water related to Qoz sands and sustained by the impervious clays below. The lower and more productive water bearing orizon is related to the Umm Ruwaba sediments. Successful boreholes usually tap water of this aquifer when they reach a level of 170 m. (600 feet) or more. The rate of successful drilling is very high and the yield is also high ranging between 700-1200 gph or more. Salinity is generally low to moderate (150-600 ppm). Salinity at Um Sot which lies very close to the margin of the graben is high (1200 ppm.).

The Tayara basin may reveal a shallower extension of the bara basin. It passes in a NW-SE direction and gets narrower in the south westerly direction (SeeFig.2). According to Ali (op.cit.) the thickness of sediments attains a maximum of 1000 m. This basin is penetrated by boreholes in Um Galabigh, El Tayara dreisa,Um Dikeika and Sheibula. In this basin the rate of borehole failure is higher than in the Bara basin. Juding

from boreholedata it is possible to drill two or more boreholes in the same depth and only one of them would be successful. The reasons for this failure are not clear and may be due to faulty drilling technique as of pluging the aquifer when drilling. This supposition is further reinforced by the fact that yield of the boreholes is moderate being between 600 and 1000 gph. Salinity is low to moderate being 200 660 ppm.

Um Sereiha basin is a much shallower part of the graben which is cut and displaced by El Hajiz fault. It is penetrated by several boreholes e.g.Um Sireiha, Samaudia, Amanalla, Abu Hamra, Kaddada,Dilgattab and Um Sireiha Bagadi. The deepest borehole is about 210 m. Since no geophysical work was done here it is difficult to guess the thickness of sediments. On the other hand there is no basis to distinguish this part of the graben from the shallow Umm Ruwaba depression. Judging from borehole data the basin is filled with Umm Ruwaba sediments resting on Nubian rocks. The Umm Ruwaba sediments are of a markedly coarse nature, with frequent beds of pebbly sands and gravels.

The yield of the boreholes ranges widely from 500 to 1250 gph., the rate of failure in boreholes is moderate. The salinity is variable from moderate to high being 400-1200 ppm.

The Umm Ruwaba basin is situated around Umm Ruwaba town and extends roughly in an east-west direction along Khor Abu Habil. The basin is apparently cut off by the Abu Habil fault (See Fig.2). The basin is penetrated by boreholes in Umm Ruwaba, Um Gezira, Um Kheirein, El Gaghan, Gideideam and Um Dibeikrat. The thickness of sediments in the basin is unknown but boreholes reached to a depth of 500 m. in Umm Ruwaba town without reaching the basement. Lithologically the sediments are characterized by the prevalence of sands and gravels over clays which usually occur in immature clayee horizons.

Boreholes deeper than 400 ft. (130 m.) give high yield ranging from 900 to 1800 gph.

The Qoz Sands :

As we have noted earlier, most of the project area is covered by a sand sheet which attains a

maximum thickness of 30-40 m. This sand sheet is fed with rain water and under appropriate conditions perched water lenses may be formed. These conditions may be summed up as follows :-

a) Perched water in Qoz areas where Umm Ruwaba clays or lacustrine deposits occur below or just below the Qoz sheet. This is a situation well developed in areas like Bara, El Kheiran and others. The depth to the perched water table varies according to the topographic position of the well. Where the Qoz sand is continuous the water table may be 25-40 m. below the surface. The shortest wells are those in dune hollows such as Bara or El Bashiri, where the water level does not exceed 10-12 m. or even less.

b) Perched water lenses in Qoz sheets overlying the basement. This is very well illustrated in the area of so called longitudinal dunes. Here the water bearing sands are underlain by the clay mantle of the basement. The thickness of the Qoz sand determines the depth and quantity of perched water. The perched water table generally follows the topographic outlines of the sand ridges, but the slope of the water table is somewhat flatter than of the sand ridge surface.

Hence the water table is deeper at the crest of the sand ridges than at the slope. Thus at Um Sireiha shallow wells dug at the sand ridges crest encounters water at 26 m. but those dug halfway up the Qoz slope usually encounter the water table at a depth of 16 m. The shape of the perched water is lenticular hence more water is drawn from wells dug at the crest of the sand ridge. The sand just above the water table is characterized by the presence of numerous cankar nodules.

An interesting variant of perched water is encountered at the contact of the sand ridges with Khor Abu Habil (e.g. at Allakareem). Here the sand wedge is sandwitched between layers of clay and a situation is created for accumulation of ground water at shallow depths (5-10 m.).

The writer is not aware of any quantitative data on perched water though most shallow wells tap only this source. Seasonal variations in water level are common but the quantity of water available depends not only on the season but on the extent of the impervious layer and the extent of the

sand sheet. Thus water is more plentiful in areas of continucus sand cover e.g. Bara than area of development of sand ridges. Perched water lenses have usually very low salinity as compared to Umm Ruwaba water.

CHAPTER IV.

EXISTING WATER SUPPLIES.

Water Provision in Time Prespective.

Provision of water-supply sources to meet the needs of rural populations had passed through many stages of development before reaching the present situation. The earliest settlements in this part of the country were founded close to the low lying scattered hill e.g. Jebel Kordofan, Wad El Baga, etc. which besides protection offered little water-supply in their vicinities in the form of pools, which lasted for a while after the rains. Settlements were also founded at places with amble surface water-supply, in the form of open bodies of water, which sometimes continue after the rainy season, such as : Bara and El Kheiran area, El Obeid, El Birka, El Bireka, Kazgeil, Er Rahad, Umm Dam, Umm Ruwaba, El Ghogan, and Sherkeila.

The dependency of the population on the above and similar sites with surface water potential, was extended with the progressive colonization of the land through the digging of open-shaft wells to obtain the sub-surface water percolating from the annual rains, or stored from the seepage of seasonal water-courses. Because of the rich supply available in most of the above mentioned centres the majority of them emerged later as places with reliable well-fields.

More settlements continued to rise away from these mentioned sites, where it was feasible to sink open-shaft wells. Most of the northern part of the project area, occupying the trough to the south of Bara, is a good example in this connection; where the extensive digging of open-shaft wells resulted in time, in intensive human habitation. As for the rest of the Project Area the development of open-shaft wells was variantly conditioned by the potential available at different localities, being mostly high in those places replenished seasonally by water-courses running during the rains.

The influence of the traditional types of water sources (rain-water collecting in different forms and open-shaft wells) on population distribution was not limited to the settled communities, but had its effects on the nomads as well. The latters' migrations in the past embraced smaller areas as compared to the present times; being well illustrated by the case of the Baggara nomads whose movement was confined to the southern half of the Project Area. The cycle of migrations of the Hawazma, Nuba, and Bederiya for example did not extend beyond El Obeid, Er Rahad and Birka. While that of the Habbaniya and Direihmat was limited to the area between Sherkeila and El Obeid.

The Abbala nomads on the other hand did not have the freedom they experience today. Their infilteration southwards was occassional and occurred only in small numbers, mostly directed and controlled by the tribal conferences, frequently held to organize grazing and the use of tribal lands by outsiders.

The dependency on these traditional sources continued till the rise of bore-holes and hafirs as important centres of supply. Bore-holes appeared in the Project Area in the first quarter of the present century; with the first tube-well drilled at Umm Ruweba in 1912. This was followed by the establishment of a number of water-yards as can be traced in Table(p.199.)However at that time these were few and quite localized.

Hafirs on the other hand assumed importance as reliable sources of water supply as from the mid of 1940's, when the Soil Conservation Board and its executive agency, The Soil Conservation Section were established. At that time the hafir was viewed as an efficient device for the effective colonization of the almost by then vacant clay and gardud plains, which remained out of reach of human habitation, because of the lack of drinking water-supply. The dispersed hafirs found at present in the southern part of the Project Area, date back to this period, plus that of the Land Use Department, which witnessed expansion in hafir programmes.

Before bore-holes and hafirs the period up to the mid 1960's also evidenced the addition of many open-shaft wells to provide supplies at places where the former two types were not successfull.

Up to this time the water-sources of all types added annually within the Project Area were limited in number, as can be judged from Table(p.199which gives the sources and its date of establishment. The real expansion in rural water supplies occurred as from 1966 and on, with the rise of the Rural Water Development Corporation, during the time of which massive programmes of bore-hole drilling were executed.

In an attempt to relate the phenomenon of environmental degradation to the expansion in water-provision programmes in the Project Area the situation can be presented as having passed through the following phases :-

Phase	Prevalent Source of Supply	Condition of Ecological Cover.
Phase I Before British Administration 1898 and up to 1915.	1. Natural Water Sources : rain-water, pools, seasonal streams. 2. Open-shaft wells.	Low land use intensity due to : smaller human population, limited distribution of human settlements, smaller number of animals, and restricted migrations of nomads; and accordingly no signs of environmental degradation.
Phase II 1916-1937	1. Natural water sources continued to be used. 2. Introduction of bore-holes but very local-ized. 3. Provision of more open-shaft wells.	Though land use intensity increased in old settled sites or around newly opened ones, there was no evidence of degradat-ion.

Phase III 1938-1955.	Besides the above listed sources, hafirs were being added as a fourth important source of supply to rural area.	The sphere of human influence was being increased by opening the clay and gardud lands for human habitation, founded on supplies from hafirs. Signs of environmental degradation reported. Awareness about its effects began building up slowly; and the provincial authorities besides the Soil Conservation Board started to be concerned.
Phase IV 1956-1966	Bore-holes, hafirs, and open-shaft wells continued to be provided in rural areas. However, the programmes executed as compared to the forthcoming phase were of smaller magnitude because of budget limitations.	While more areas were opened to intensive use due to the addition of more water-sources every year; the process was accompanied by improvement in the planning philosophies and procedures resulting in the long run in the adoption of an interdisciplinary approach in the preparation of the water provision programmes. Degradation continued but under controlled conditions, partly due to the limited number of new sources added annually, and partly to the strict criteria used in the selection of the new sites to be supplied with water.

Phase V. 1967-1976.	1. Execution of massive programmes in bore-holes. 2. Provision of less number of open-shaft wells. 3. Decline of hafir excavation programmes, which with the years resulted in the complete neglegence of this type of source.	This is the time the question of water-supply for rural areas was pushed forward to become a national issue. Soon it began to have political implications. Almost all of the proposed sites that were geologically favourable were usually drilled; while those with dry acquifers received no supply. The political element which accompanied the process slowed down the strict land use planning and control measures. Degradation accelerated at a phenomenal rate due to the extensive opening of many localities to human and animal use. The natural increase in human and livestock populations found outlets in the newly opened areas, with signs of over cultivation and overgrazing manifesting themselves every where.

Phase VI 1977 and on.	1. The political consequence attached to water provision programmes subsided. 2. Bore-holes continue as the main source catered for in the annual programmes, with open-shaft wells ranking next, while the state of neglegence of hafirs is increasing. However the number of bore-holes annually drilled has been cut down drastically in comparison to Phase V, mainly because of budgetary cuts.	The same trends of degradation described in the preceding phase persist. The maintenance of water-yards has become an over-riding problem. The continuous breakdown together with lack of fuel put many of them out of operation. The resultant rest period may slow down degradation for a while. The rise of regional governments like the one of Kordofan is increasing the concern about environmental changes and the decline in the natural resource base. Programmes like DECARP and Hashab Rehabilitation are highly valued in this respect.

Criteria for Programme Formulation :

The preparation of the water provision programmes in terms of sources of supply, geographical coverage, sizes of populations served, etc. has been accompanied by a continued development in the philosophies which guided water supply for rural areas. As a result, there has been much elaboration in the planning procedures used. These developments aimed continually at achieving two objectives : (i) equitable allocation of the programme at provincial, rural council, and site levels to insure that the most eligible communities to new sources are given priority; and (ii) that the newly added supply does not become a source of deterioration to the ecological cover of the area in which it has been provided. To what degree these two objectives have been met shall be discussed next.

Reviewing the development of the planning philosophy, approaches, and techniques which accompanied water programming throughout the differerent phases outlined previously, we come across :-

Phase I : Water provision was purely a community effort involving the protection of the existing sources, and the search and development by the population of new sources, mainly open-shaft wells.

Phase II : (i) Open-shaft wells were provided by provincial and district authorities by working gangs employed for the purpose; while community efforts in providing the same sources continued. The decision on new sites for well excavation was made according to need priorities; which is an indirect way helped in strengthening the administrative infra-structure.
(ii) Bore-hole drilling at the time was carried out by the Drilling Division of the Department of Works. Sites of bore-holes were decided upon by provincial authorities; again to meet community needs and to serve strengthening the administrative infra-structure.

Phase III: (i) Provision of open-shaft wells and bore-holes continued under same philosophies and planning method as outlined in previous phase.
(ii) Hafirs introduced to open the clays and gardud lands for human habitation. This was followed by realizing the need for land use planning, which relates water provision to the optimum utilization of natural resources. As a result surface water engineers and agriculturists were employed for the task, to form the nucleous of the land use planning teams that emerged later.

Phase IV: (i) During this phase the Land Use and Rural Water Supplies Department was created, by amalgamating the Soil Conservation Section, and the Drilling Division.

For the first time provision of water sources, became the responsibility of one government agency; with the exception of open-shaft wells which in many cases were catered for by district authorities as well.

(ii) During this phase the emerging trend of integrated land use planning, referred to under the previous phase, was further strengthened by adding disciplines from the socio-economic field.

Phase V: (i) Expansion of the technical capabilities of the Rural Water and Development Corporation including land use planning.

(ii) Application of land use planning criteria to nearly all water sources provided; however there were no control measures to reduce the negative impact of water sources, being the non-concern of any specific government unit. This lack of concern has been the major factor behind the accelerated ecological deterioration witnessed during the last 15 years.

Phase VI: (i) Same above trends as in Phase V.

(ii) Emergence of regional governments, with signs of rising awareness about the present stage of devastation reached by natural resources; besides the appearance of a number of environmental rehabilitation projects.

It seems that the major factor which has expedited environmental degradation, especially in the rain-fed belt of Central Sudan, in which the Project Area falls, has been the absence of controlled use of land resources around these water-points after they are being provided. The kind of land use planning applied by the Land Use Department and on the basis of which the proposed sites for water provision are evaluated, examines the favourability of each site from ecological, land use and human habitation angles, at the time the site is proposed for inclusion in the annual programme. It stops at this stage, and when the site is provided with water, the monitoring of the land use around it becomes the responsibility of no body.

The criteria applied for ranking sites for selection for the annual programme include :

i) Review of the present situation of water-supply proposed area, embracing as well as general evaluation of the existing water sources in its surroundings, to assess the adequacy of all available sources in meeting the needs of the area.

ii) Survey of the physical conditions of the environment around the site, involving the study of the climate of the area, its soils, vegetation etc.,

to be used as a basis for investigating the signs of environmental deterioration due to physical and human factors; so as to assess the vulnerability of the proposed site to further deterioration if it is supplied with water.

iii) Assessment of the water requirements of the site, by estimating the human population and the livestock numbers which shall depend on it; including the nomads who utilize the area if there are any.

iv) Appraisal of the land use potentialities of the area, with emphasis on the future impact of water provision on increasing production, through the stability it gives to the population.

v) Study of the situation of the social and economic services in the area such as schools, dispensaries, public posts, co-operatives, etc.. to weigh the need of the area for such services, and whether the provision of water shall help in attracting these facilities to the area.

Usually by applying the above criteria, many of the sites which are proposed by local communities for water provision, are declined a new supply, for the sole factor of observed severe environmental deterioration. Yet, in

the majority of sites recommended it has been the case that the positive impact of water provision, are pushed forward as against the negative impacts. The main driving force behind this predicament has been the concern of central and regional authorities about the improvement of rural life through the provision of adequate and hygenic water supply.

No body argues against providing that adequate amount of water required to meet the needs of population and that of livestock in a given area; being essential for maintaining a productive economy, and improving the general welfare of the population. But this continued to be an assumed target, with little comprehension from both planners and executors, who overlook the fact that this goal can only be realized through well conceived integrated natural resource planning, that aims at bringing the areas that are served by the newly furnished water-points under controlled use of resources. Because of this omission occurs the dilemma faced at present in the area of natural resource conservation and use, which prevails inside and outside the Project Area; usually starting the day a water-yard is put into operation. This consequence of water-provision shall remain the challenge to any programme aimed at the improvement of the water-supply situation in an area through rehabilitating the existing sources or catering for new ones;

especially true if the programme is to be carried out in the context of sound land use planning, to guarantee a balanced utilization of resource to accompany the newly provided water-supply.

Existing Water Situation :

Against the above background on the historical development of water provision in the Project Area, and the review of the planning philosophies and approaches applied, the existing water-supply situation shall be discussed.

Fig. 1 gives the distribution of water-sources in the Project Area. The data is complete for bore-holes and hafirs, which is not the case for open-shaft wells, since the latter one definitely more in number than the areas shown on the map. There is difficulty in inventoring all of the existing open-shaft-well sites, for two main reasons. First, they are widely present, and secondly many of them do not qualify as reliable sources, since the site may be excavated one year and abandoned the next one.

The geographical distribution of the available sources as exhibited by Fig. 1 shows patterns that can be used for dividing the Project Area into 7 main zones, reflecting the influence of the geological and geomorphological factors accounted for earlier.

A further examination of the state of water-supply in these zones in relation to the physical factors reveals the following picture :-

Zone I : This zone is underlain by Basement Complex and overlain by sands some clayey sands. Water supplies are limited to few hafirs and some natural depressions. Most of the inhabitants get their drinking water supplies from tankers or cisterns owned by village traders. It is an area of severe water shortage.

Zone II : This zone from geomorphic point of view is described as El Obeid emerging pediplain. It is intensively fractured with many Khors and water courses, a fact of great significance in relation to water supplies. The zone is covered by different soil types ranging from sands to loamy sands and clays. Water-yards are limited to the area south of El Obeid along the khors while the rest of zone experience severe water shortages especially during the dry season.

Zone III : It is a zone of contact between Umm Ruwaba formation and Basement Complex overlain by sands or clays. Groundwater is difficult to find, if found the yield is low, so most sources in this zone are hafirs and some traditional shallow wells along wadi beds. It is also a zone with large number of villages with no water supplies.

Zone IV : It is the zone of the ancient Umm Ruwaba drainage system covered with sands and leading to the creation of longitudinal dunes alternating with troughs. water is provided by numerous wateryards and shallow wells. The zone is adequately supplied with water.

Zone V: Geomophologically this zone is similar to zone IV but field observations have showed that the sand ridges in this zone and their alternating troughs are underlain by basement rocks. Water supply is limited to few hafirs. The inhabitants used to travel long distances to get their drinking water.

Zone VI: Geomophologically this zone is an extension to zone II. The most widespread superficial deposit is clay which provide good locations for hafir construction. Beside the hafirs a number of shallow wells are also found along khors and water courses.

Zone VII: This zone is underlain by Umm Ruwaba formation and covered with transverse dunes and sand sheet. It is adequately supplied with water from wateryards and shallow wells. It is also the most degraded zone.

It is evident from the above account that there are gap areas in the water provision map of the Project Area, being more prominent in its western half, comprising zones I, II, III, V, and VI.

The data in Table 5.11 and population envelopes served, in Fig.13, confirm the same conclusions on the inadequacy of existing water-sources in meeting human habilation requirements in the above listed zones.

It is apparent that the shortage of supply in at least 4 out of the 7 zones (I, II, III and VI) is directly related to the poor water potential in these areas; being due to the absence of water bearing acquifers, or the lack of sub-surface storage.

The solution to the water-supply problem of these areas shall require more indepth hydrogeological studies that definitely involve resource and time budgets outside the scope of the present study. Short term solutions to alleviate the hardships through which the human communities inhabiting these areas live at present, entail some creative work, to locate places for digging open-shaft wells, besides harnessing rain-water and storing it at sites where hafir development is feasible. It is to be noted in this respect that these newly added sources shall solve the problem only partially, since their geographical location might not be compatible with that of the present distribution of population. However, if such sources are provided, they shall definitely cut on the distances travelled at present by the village communities to obtain their supply, besides they shall

prolong the stay of many populations in their villages up to mid-dry season whereby they can better attend their cultivations, and Hashab gardens. Further more, they may attract people from the existing villages to settle permanently around them, and therefore result in changing the present population distribution densities.

As for zones V and VI, apart from, the applicability of the solutions recommended for the above 3 zones (I, II, ~~and~~ III) to them, zone V has a bigger surface water-potential in the Rahad Turda from which supplies can be extended especially to the east, and in hafir development in the clay strip running to the south of the railway line. While Zone VI commands a similar potential for hafir excavation in the extensive gardud and clay plains, beside the many drainage lines found in the area.

Zone IV and VII are the last to be treated. They present little problems in terms of water provision, since they have a better potential as compared to the ones tackled before. Zone VII is an area favourable for the development of open-shaft-wells plus bore-holes where the solution to new village supplies is therefore readily available. While Zone IV is an area served by bore-holes, which makes it feasible to recommend new sites to meet new demand for water.

CHAPTER V.

LAND USE AND HUMAN ACTIVITY.

In what follows the various forms of land use present in the area shall be accounted for and related to the natural resource bases on which they rest. The evident land use types are : (a) Crop production, (b) Forestry, with emphasis on the hashab (Acacia senegal) culture and gum production, and (c) Livestock raising. Fig. 8 displays the distribution of the above types of land uses in the Project Area.

Closely associated with the land use systems are the human activities and the population distribution in the area. These shall be examined in the second section of the present chapter. In course of the analysis the human environmental impacts in relation to the land use types, with special reference to the role played by water-supply in this respect shall be considered.

Crop Production :

Crop Distribution :

The crops produced in the Project Area fall under two main categories : (a) Staple food crops, and (b) Commercial crops. The former consists of dukhun millet, Pennisetum, and dura Sorghum. The second include sesame, Sesamum orientum, groundnuts, Arachis hypogea, Kerkade Hibiscus

sabderiffa, water-mellons Colocynthis citrullus, Lubia Dolicus lablab and cotton in very limited amounts. [illegible] produced on the tein and [illegible] limited expansion. Of the commercial crops sesame is the most prominent followed by groundnuts, Kerkade and water-mellons in the above order. Cotton is of special presence in the Project Area, being grown in Abu Habil Scheme to the south of Simeih.

Figs. 6 and 7 gives the distribution of crops in the Project Area, based on the combinations produced by village; as supplied by survey findings. A full picture of the same aspect is given in Tables 5.1, 5.2 and 5.3 which lists all zones surveyed and the crop combination for each.

It can be depicted from Figs. 6 and 7 and the tables that all of the Project Area to the north and east of the railway line: Umm Ruwaba-El Obeid, and north of that is a a predominantly dukhun and sesame producing country. In comparison the rest of the area lying to the south and west of the railway line produces dukhun, dura and ground-nuts. As for Kerkade and water-mellons these are to be found in the two sub-divisions with a variant distribution.

Table 5.1.

Areas of Grown Crops Per Family (Dura and Dukhun).

Area in Mukhamas Zone.	DURA										DUKHUN									
	1-4		4-9		10-14		15-19		20+	TOTAL	1-4		5-9		10-14		15-19		20+	TOTAL.
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%
I	2	33.3	4	66.7	-	-	-	-	-	6 100	3	23.1	4	30.8	3	23.1	1	7.7	2	15.4 13 100
II	4	30.8	7	53.8	2	15.4	-	-	-	13 100	10	40.0	8	32.0	6	24.0	-	-	1	4.0 25 100
III	7	58.3	3	25.0	2	16.7	-	-	-	12 100	13	48.1	10	37.0	4	14.8	-	-	-	- 27 100
IV	11	34.4	17	53.1	3	9.4	-	-	1	3.1 32 100	18	38.3	20	42.6	6	12.8	2	4.3	1	2.1 47 100
V	17	63.0	9	33.3	1	3.7	-	-	-	- 27 100	20	66.7	8	26.7	-	-	1	3.3	1	3.3 30 100
VI	5	71.4	2	28.6	-	-	-	-	-	- 7 100	13	48.1	11	40.7	3	11.1	-	-	-	- 27 100
VII	-	-	-	-	-	-	-	-	-	- -	4	20.0	9	45.0	5	25.0	-	-	2	10.0 20 100
Total	46	47.4	42	43.3	8	8.2	-	-	1	1.0 97 100	81	42.9	70	37.0	27	14.3	4	2.1	7	3.7 189 100

Table 5.2.

Areas of Grown Crops Per Family (Sesame and Groundnuts).

Areas in Mukhamas / Zone.	SESAME										GROUNDNUTS.									
	1-4		5-9		10-14		15-19		20 +	TOTAL	1-4		5-9		10-14		15-19		20 +	TOTAL
	No:	%	No:	%	No:	%	No:	%	No: %	No.: %	No:	%	No:	%	No:	%	No:	%	No: %	No.: %
I	3	21.4	8	57.1	1	7.1	-	-	2 14.3	14 100	5	83.3	1	16.7	-	-	-	-	- -	6 100
II	5	17.9	7	25.0	6	21.4	4	14.3	6 21.4	28 100	9	90.0	-	-	1	10.0	-	-	- -	10 100
III	4	13.8	17	58.6	4	13.8	3	10.3	1 3.4	29 100	8	100	-	-	-	-	-	-	- -	8 100
IV	11	20.0	23	41.8	14	25.5	3	5.5	4 7.3	55 100	5	100	-	-	-	-	-	-	- -	5 100
V	4	13.3	16	53.3	9	30.0	1	3.3	- -	30 100	20	90.9	1	4.5	1	4.5	-	-	- -	22 100
VI	17	65.4	8	30.8	-	-	1	3.8	- -	26 100	19	79.2	1	4.2	-	-	4	16.7	- -	24 100
VII	3	15.0	11	55.0	3	15.0	-	-	3 15.0	20 100	-	-	-	-	-	-	-	-	-	- -
Total	47	23.3	90	44.6	37	18.3	12	5.9	16 7.9	202 100	66	88.9	3	4.0	2	2.7	4	5.3	- -	75 100

Table 5.3.

Areas of Grown Crops Per Family (Karkadai, Water-Mellons & Home Garden).

Area in Mukhamas / Zones	KARKADAI						WATER MELLONS						HOME GARDEN					
	1-4		Inter-cropped.		TOTAL		1-4		Inter-cropped.		TOTAL		1-4		Inter-cropped.		TOTAL	
	No.	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%
I	1	100	-	-	1	100	2	40.0	3	60.0	5	100	1	33.3	2	66.7	3	100
II	-	-	-	-	-	-	2	100	-	-	2	100	1	100	-	-	1	100
III	7	43.8	9	56.3	16	100	9	100	-	-	9	100	10	100	-	-	10	100
IV	9	28.1	23	71.9	32	100	1	6.7	14	93.3	15	100	10	100	-	-	10	100
V	15	71.4	6	28.6	21	100	2	20.0	8	80.0	10	100	7	87.5	1	12.5	8	100
VI	3	100	-	-	3	100	-	-	-	-	-	-	2	100	-	-	2	100
VII	-	-	-	-	-	-	1	100	-	-	1	100	-	-	-	-	-	-
Total	35	47.9	38	52.1	73	100	17	40.5	25	59.5	42	100	31	91.2	3	8.8	34	100

Farming Patterns :

Village land for different uses including cultivation is under a communal tenure. Its boundaries are normally to the village by natural land marks, recognizable to the other adjoining villages. An estimated sphere of human influence of 3 to 5 Km. around a village seems to be about the average land use raduis.

Crops are produced under shifting cultivation practices; whereby a land holding is cultivated for a number of years (6-8) after which it is left to rest; meanwhile a new parcel of land is put under cultivation.

The family being an extended or a nuclear one is the production unit; usually cultivating 1 to 2 holdings; all depending on the labour and finance available to it.

Farm Sizes :

Farm sizes vary considerably as revealed by the figures in Table 5.4. Apart from the labour and finance available to the family, already mentioned, other factors which influence the farm size are the soil type, plus the situation of drinking water supply in the villages during late dry season and the harvest time.

Since all operations are done by hand and the sandy soils are easier to till compared to the clays and gardud soils, farm sizes increase under the former soil type, as

Table 5.4.

Farm Size Per Family (in Mukhamas).

Area / Mukhamas / Zone	1-4		5-9		10-14		15-19		20 +		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	-	-	1	7.1	5	35.7	2	14.3	6	42.9	14	100
II	1	3.4	3	10.3	5	17.2	9	31.0	11	37.9	29	100
III	-	-	5	17.2	12	41.4	5	17.2	7	24.1	29	100
IV	-	-	7	12.7	16	29.1	13	23.6	19	34.5	55	100
V	-	-	-	-	9	30.0	9	30.0	12	40.0	30	100
VI	2	6.5	12	38.7	11	35.5	3	9.7	3	9.7	31	100
VII	1	4.8	4	19.0	5	23.8	5	23.8	6	28.6	21	100
Total	4	1.9	32	15.3	63	30.1	46	22.0	64	30.6	209	100

Crop Distribution :

What the farmer grows annually is influenced by a number of factors which have their imprints on the distribution of crops grown in the fields. Among these forces we find :

(a) The soil type and its suitability to certain crops; e.g. dukhun on sandy soils versus certain varieties of sorghum (fetarita) on clay or gardud soils, or groundnuts on more faragile sands as compared to sesame on more compacted sands,

(b) The dietary habits of the population; while some prefer to feed on dukhun, othershave preference to dura,

(c) The return opportunity of one commercial crop in relation to another, as judged from the price behaviour of the last few years,

(d) The labour available to the household, since certain crops such as groundnuts require intensive labour input for weeding; or Kerkade which need more hands for the harvest operation.

From Table 5.1 referred to earlier, it is evident that almost all farmers grow staple food plus some commercial crops, (Sesame, Groundnuts and Karkadei). Up to few years back more land was put under commercial crops as compared to staple foods. The deficit in the

family dura supply when not met from its own production was made for from purchases of additional quantities from the market. The shift to the production of more staple foods is mainly due to rises in the prices of the latter in recent years coupled with the scarcity in supplies especially during the rainy season.

Crop Rotation :

Cultivated land in this area can be classified as Saraya and Bura. The former is usually used to mean a clean field that has been put under cultivation for a continuous number of years; while the latter applies to a newly opened land that was under fallow. A Saraya land is easy to cultivate compared to a Bura, especially with regard to the weeding operation. Under the system of shifting cultivation practiced in the Area the two types of land are interchangeable, since with the Saraya losing its fertility in time, it is replaced by the Bura which is brought under cultivation from a fallow condition.

This interchanging of land involving a resting period and then bringing it back under production after some years is essential for the rejuvenation of the hashab trees as shall be discussed in more detail later.

Soil fertility and the degree of clearness of land influence crop rotation. A Saraya land is mostly put under cash crops, while the Bura is cultivated in the

first years with dukhun. Compared to commercial crops dukhun tolerates more the presence of weeds in the first years when the Bura is newly opened. Accordingly crop rotation follows this sequence :

Dukhun/dura 2-3 years ——— Sesame/Groundnuts/Kerkade 4-5 years ——— fallow 8-10 years.

As for water-mellons, Lubia and Kerkade (in case the latter is not grown in a separate field) these are intercropped with food as well as commercial crops.

The above sequence gives the general picture. There are definitely variations in the time span for changing land from one crop or type of use to the other, between the different parts of the Project Area. A number of factors are behind the occurrence of these variations including shortage in land available for cultivation which can be attributed to :-

(a) Natural increase in village population with the resultant reduction in the carrying capacity of the land;

(b) Expansion in the production of commercial crops through the use of hired labour, especially by financially able families;

(c) The two above factors are directly related to the impact of water-supply sources which intensify

farmers improved seeds of groundnuts on credit, which were collected after harvest.

The implements in use are rudimentary, and basically depend on human exertion. The Fas 'ax' and the Baraza 'rake' are the ones used in cleaning the land. Seeding is done by the Toriya 'hoe' in sandy soils, and the Saloka a kind of digging stick in the clays. Weeding is carried out by the Hashasha. For cutting the dukhun, dura, sesame and Kerkade the Mungal 'ciessel' is in use; while groundnuts is harvested by pulling the bushes from the soil.

All crops mentioned with the exception of Kerkade are then heaped in one form or the other and left to dry up. Except for sesame which is treated differently by shaking the dry plants to separate the produce from the stalks, other crops are beaten by the Mudgag and after that winnowed to obtain the produce.

Nearly all of the above farm tools are made locally in the area; and are purchased by farmers from the near-by rural markets. Being low in efficiency they present a handicap to increasing production through horizontal expansion.

Labour is the other basic farm input which remains to be treated. To produce the crops discussed above, the majority of families rely on their own labour. Few resort to hired labour from outside the family. Among

the latter category are the village merchants who cultivate annually large areas of commercial crops. There are also the comparatively prosperous families who invest their savings in agriculture putting under production additional acreage through the use of hired labour. The number of such families increased in last years due to the readily available finance generated from migrations for employment.

In connection to labour availability, the traditional system of co-operation the Nafir was an effective device in mobilizing additional labour for the family up to very recent times. The system works on receiprocal labour exchange. Usually the head of the household would invite fellow-villagers on a specific day to his field, to help in carrying out one of the agricultural operations; most frequently weeding. In return for their labour he offers them food including sometimes marisa, a locally brewed drink. With the charge towards moreindividualistic relations, and the rise in costs of foods the Nafir, though is still practiced, is losing its importance compared to the role it assumed in the past.

Since agriculture depends on family labour all the available hands from both sexes are fully utilized for the purpose. Out of the 7 members, being the average size of the household in the study area, about 5 (father, mother, plus three children) are to be found fully engaged in managing production. Some division of labour is evident.

Clearing the land is the work of the father plus the elder sons. Preparing the holes for seeding is carried out by the father, while putting the seeds in the holes is done by the rest of the family. Weeding is the work of all able members of the household from both sexes. The same is true for the harvesting of crops to which everybody contributes, with the specific role of women in winnowing and separating the produce from the crop remains.

Agricultural Calender :

Reliable rains for cultivation fall in the period July-September. Farming activities and the calender of agricultural operations follow closely the rainfall regime.

As early as April, and throughout May and June, farmers are engaged in preparing their fields. This operation involves collecting and burning the left over from last crops in the Saraya land; and the cutting and burning of trees and herbage in the newly opend Bura land. Here as mentioned before the stability of the household in the village, eminating from a secure source of drinking water-supply in proximity facilitate very much early field preparations; as compared to the situation whereby a household is away from the village fetching for water during the dry season, and only returning to the village on the onset of the rains.

Two types of sowing are practiced by the farmer : rameil which is sowing before the rains, and the usual sowing operation practiced after the fall of some reliable showers. The first is attempted as early as the beginning of May, and continues throughout June; while the latter is carried out in July. The first has the advantage of taking chances of any rains that fall before July, enabling therefore the early establishment of the crops. The practice has its disadvantages as well. It is very usual that the seeds are destroyed by pests; besides, prolonged intervals of drought after the seeds have sprouted cause the death of the young crop. The result is that seeds are lost to the farmer. Since the majority of farmers are not in a position to provide for seed substitutes to reseed their land in case such failures occur, rameil is mostly practiced by the well-to-do households.

Sowing is followed by resowing to establish the crop in those fields or locations in a field where the seeds failed to show good germination for one reason or the other. The operation is carried throughout the whole of July, and sometimes it is continued up to the middle of August, all depending on the behaviour of rainfall in any particular year.

About 15 days after sowing, the weeding operation starts and normally continues up to the end of August. Two weedings are necessary for establishing the crop in the saraya land, while an additional third weeding is required in the case of the bura land. The first weeding is called El Mur (literally: bitter) meaning that it is a hard operation to carry out as it requires much human exertion. The second is referred to as Jankab usually demanding less efforts.

Of all farm activities weeding is the key operation on which the success or failure of a crop stands. Therefore it has to be carried out in time, which means when the weeds are just sprouting. If the operation is delayed till the weeds become established, much effort is needed after to erradicate them; and at later stages they might take over the crops. That is why a farmer cultivates that area which he and the members of his household can effectively weed. Therefore and as raised before the labour available to the family is the number one factor controlling the acreage cultivated. Accordingly any extra-land put to cultivation beyond the working ability of the family is managed through hired labour. Very often poor families are characteristically faced with the problem of being unable to weed in time, because they are often compelled to sell part of their labour to others,

and only partially devote the rest to their own fields; particularly so in a year that follows a bad harvest.

The harvesting of crops starts in October and continues up to February. The quick maturing varieties of dura nagad and sesame hereihri are harvested first. Groundnuts is harvested next. While dukhun, kerkade and the slow maturing varieties of dura and sesame, and water-mellons are harvested last.

Yields Level :

Yields of various crops are affected by a number of factors, mainly the level and distribution of rainfall, the soil fertility, pests and diseases, the labour input and the timing and efficiency in carrying out the various operations.

Gum Production :

Gum production in the Study Area is important from two angles : as a cash crop which adds substantially to the income of the farmer, and as a tree cover for maintaining the vegetation of the area. Though the farmers' main concern in growing hashab centres around its economic return, yet most farmers are aware of the second role played by the tree.

Gum is produced from the acacia senegal tree, known locally as hashab. The tree is found growing at variant densities on nearly all of the sandy soils of the Study Area, while it disappears in the gardud and clay soils where its place is taken by other species such as : Kitir Acacia millefra, Laot Acacia nubica and the likes.

Considering the intensity of distribution of hashab within the Project Area, it is most dense in the central parts of the Area, occupying the zone between Umm Ruwaba and Er Rahad to the north of the railway line up to Keddada. Besides this zone there is another smaller one to be found to the north of El Obeid around Taloshi. Other minor areas can be cited here and there. Fig. 9 exhibits its distribution within the Project Area at time of survey and Fig. 10 shows its distribution in 1966.

Prior to the occurence of the phenomenon of intensive degradation to which the ecological cover in this part of the country has been subjected, dating back to the last 10-15 years, hashab occupied larger areas as an established vegetation association in terms of areal extension and intensity. Gradually it began to disappear from many areas and the situation;has become alarming to the degree which necessitated the implementation of the hashab rehabilitation programme, presently in progress.

There are many factors behind the decline of hashab which can be accounted for under :-

i) The resultant pressure on land for cultivation due to the natural increase in the farming population; coupled with the expansion of the acreage cultivated per household following the production of commercial crops; with both factors leading to the confusion of the cultivation cycle, cutting on the years devoted to hashab in the rotation.

ii) The degradation of the hashab tree as part of the vegetation cover in Kordofan Region, attributed to heavy human use of trees especially for fuel wood, charcoal, and building materials; with the effect being more severe in those areas accessible to the market towns and the small rural centres. The hashab tree in relation to the three mentioned uses is rated as second in quality of species such as Kitir, Acacia mellifera, Sunut, Acacia nilotica; and Subbagh for building material, and arad Albizzia amara for fire-wood and charcoal production.

iii) The effects of natural and human hazards including drought, insects, locust and fires. The damage caused by the latter two is evident, and

can be traced and proven, especially the loss of of large hashab areas due to the neglegence of fire-lines in the last 10 years. As for the first two, though there is not yet concrete evidence pointing to their direct effect, both are preceived in most villages surveyed as behind the retreat of the hashab cover.

iv) Connected to the above hazards, but deserving special mention is the devastation caused by the camel raising nomads; who cut the branches of hashab trees, mostly the young ones, as browse material and feed their camels. They usually do this towards late dry season, at a time the tree needs all of its stored energy to maintain its continuity up to the beginning of the rains; a practice which damages the trees sometimes to an unrecoverable stage.

v) Shortage of drinking water-supply in areas of high hashab production, being remote from water points at a time secure supplies are required to maintain the producers, as from December and on.

vi) The competition between gum production and the other sectors of employment especially those available in the irrigated schemes and the urban areas outside the Region, over the labour force

Coming now to the role played by hashab in the ecological cover of the area, it is evident that hashab as a tree culture assumes an important place in the shifting cultivation system practiced in the Study Area. It is fitted by the farmer in the crop production rotation in a cycle of approximately 18 years from its growth as seedlings or coppice shoots, to the time the trees reach old age and become out of production. Hashab plantations pass through three stages in their development :-

i) An establishment stage whereby the young trees are nursed by the farmer in the same land under cropping, or in a land which is bur;

ii) a production stage as from the age of 5 to 6 years which continues up to the age of 14; and

iii) a decline stage which lasts for about 4 years.

By then the old plantation is cleared for cultivation as a newly opened bur land, and accordingly a new cycle in the rejuvenlation of hashab starts.

Livestock Raising :

Livestock is raised in the Project Area by both the settled populations and the nomads who enter the Project Area from the regions lying to the north and south of it. For many of the settled communities the rearing of animals is complementary to crop production, with its role increasing in importance in the last 10-15 years.

The main animals raised by the settled communities are goats, cattle, and to a lesser degree sheep; besides donkeys. The goat is the most prevalent animal in the villages, with families owning 2-5 goats. It is kept for its milk, and as an occassional source of cash and meat when need arises. Being a tough animal it tolerates the hard conditions of the Area, especially the period of late dry season, when grazing and water supply become scarce.

Cattle does not match goats in numbers, however it increased tremendously in the last decade. The change has come as a result of two major factors : (a) the recent expansion in rural water supply programmes which yielded hundreds of newly erected water-yards, and, (b) the accumulation of savings which has been directed to the building of herds. One of the forces that strengthened this trend has been the limited returns from agriculture, which being open to frequent failures, besides the fact that investment in crop production reaches its ceiling after few increments encouraged the locals to concentrate more on livestock raising. The same factor has also added to the building of sheep numbers, especially in the northern and southern parts of the Project Area, where there live populations who come originally from sheep raising culture such as the Dar Hamid tribal groups and

the Fellata of Southern Darfur who migrated to the area at the turn of the century. Among some of these communities sheep raising is practiced as a trade. Families with cash surpluses buy lambs from villagers and the nomads, and raise them on the available herbage plus other feeds during the dry period, and keep them throughout the rainy season, to sell them in October-December to livestock traders.

The other important animal found in the villages is the donkey with most families owning one at least. Their number increases in those villages which lie at long distances from water sources. Here a family owns up to 3 beasts, to carry the amounts of water needed by the household. As the task of transporting water is very hard, especially when the source of supply is far from the village, donkeys are used alternately; with one or two animals visiting the water point every other day. Because of the same factor villagers often borrow water from neighbours, and give it back when their donkeys bring supplies from the water source. Villagers remark that the number of donkeys has been decreasing in recent years and attribute that to natural death, because of the hardships the animal is subjected to, in transporting water throughout the hot dry months.

Considering camels these are few in numbers, not exceeding 3-7 per village. Their numbers used to be greater in the past up to the mid 1950's, when they were the main means of transportation between the villages and the market centres. The increase in the use of lorries has led to a reduction in their numbers. Presently the few that are found are utilized in carrying the crops from the farms to the villages, and in other petty jobs such as the transportation of fuel wood, charcoal, straw, fodders, etc. from the villages to the market places; besides of course their use in moving the traditional oil-pressers.

When we come to the question of animal figures, it is difficult to supply any numbers for village ownersip that are close to reality. Taxation records are out-dated and the figures supplied by them drastically under estimate the actual numbers. An attempt at some estimates for the villages surveyed are supplied in Tables, 5.5, 5.6 and 5.7.

As for the nomadic groups, the Area is visited alternately by the cattle nomads (the Baggara) migrating from the south during the rainy season, and the camel nomads (the Abbala) infilterating from the north during the cool and dry season.

Table 5.5.

Number of Animals Owned by the Family (Cattle & Sheep).

No. of Animals / Zones	CATTLE. None		1-2		3-4		4 +		Total		SHEEP. None		1-2		3-4		4 +		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	12	80.0	-	-	1	6.7	2	13.3	15	100	12	80.0	1	6.7	-	-	2	13.3	15	100
II	21	70.0	-	-	2	6.7	7	23.3	30	100	27	90.0	1	3.3	-	-	2	6.7	30	100
III	16	55.2	4	13.8	4	13.8	5	17.2	29	100	27	93.1	-	-	-	-	2	6.9	29	100
IV	36	65.5	2	3.6	6	10.9	11	20.0	55	100	42	76.4	6	10.9	1	1.8	6	10.9	55	100
V	21	67.7	3	9.7	3	9.7	4	12.9	31	100	27	87.1	1	3.2	2	6.5	1	3.2	31	100
VI	16	50.0	2	6.3	2	6.3	12	37.5	32	100	19	59.4	1	3.1	1	3.1	11	34.4	32	100
VII	20	95.2	1	4.8	-	-	-	-	21	100	12	57.1	-	-	-	-	9	42.9	21	100
Total	142	66.7	12	5.6	18	8.5	41	19.2	213	100	166	77.9	10	4.7	4	1.9	33	15.5	213	100

Table 5.6.

Number of Animals Owned by the Family (Goats & Donkeys).

No. of Animals / Zones	GOATS										DONKEYS									
	None		1-5		6-9		9 +		Total		None		1-2		3-4		4 +		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	2	13.3	6	40.0	3	20.0	4	26.7	15	100	-	-	13	86.7	2	13.3	-	-	15	100
II	6	20.0	15	50.0	1	3.3	8	26.7	30	100	14	46.7	16	53.3	-	-	-	-	30	100
III	6	20.7	11	37.9	7	24.1	5	17.2	29	100	5	17.2	17	58.6	5	17.2	2	6.9	29	100
IV	15	27.3	31	56.4	6	10.9	3	5.5	55	100	7	12.7	42	76.4	4	7.3	2	3.6	55	100
V	3	9.7	15	48.4	7	22.6	6	19.4	31	100	4	12.9	23	74.2	4	12.9	-	-	31	100
VI	8	25.0	9	28.1	4	12.5	11	34.4	32	100	5	15.6	25	78.1	2	6.3	-	-	32	100
VII	3	14.3	4	19.0	3	14.3	11	52.4	21	100	3	14.3	13	61.9	5	23.8	-	-	21	100
Total	43	20.2	91	42.7	31	14.6	48	22.5	213	100	38	17.8	149	70.0	22	10.3	4	1.9	213	100

Table 5.7

Number of Animals Owned by the Family (Camels).

No. of Animals / Zone.	None		1-2		3-4		4 +		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
I	11	73.3	4	26.7	-	-	-	-	15	100
II	21	70.0	9	30.0	-	-	-	-	30	100
III	19	65.6	10	34.5	-	-	-	-	29	100
IV	39	70.9	15	27.3	-	-	1	1.8	55	100
V	25	80.6	6	19.4	-	-	-	-	31	100
VI	27	84.4	5	15.6	-	-	-	-	32	100
VII	10	47.6	11	52.4	-	-	-	-	21	100
Total	152	71.4	60	28.2	-	-	1	0.5	213	100

The former group includes : the Hawazma, the Nuba, the Bederiya, the Habbaniya, and the Direihmat. They begin entering the Area in the middle of July, and establish themselves in the zone of gardud soils to the north of Er Rahad and east and west of the railway line up to the outskirts of El Obeid. They move in two thrusts. The Hawazma, the Nuba and the Bederiya coming from the Nuba Mountains region enter the project Area from the south; while the Habbaniya and the Direihmat migrating from El Abbassiya and Sherkeila areas enter the Project Area from the south east.

Gradually they establish their encampments in this extensive plain of gardud land, which is thinly populated, being poor in water supply potential, natural or man-made; besides its favourable land surface for the stay of cattle during the rains as it is well drained, providing thus dry under-foot for the animals. Though it has few water sources during the dry season, it has adequate supplies during the rains collecting in pools, and available in the many water-courses transcending the area.

The Baggara groups occupy this wet season grazing belt up to early October. During this time they sell the milk from their herds to the cheese processing units, which with time multiplied in number to reach about 25 units at present. This is also the time they sell some

animals at El Obeid Livestock Market. The income generated from the sales of milk and livestock is used in purchasing food necessities, payment of taxes, maintenance of cultivations to the south of the Project Area, and in buying productive cattle.

By early October the Baggara dismantle their camps and begin their return journey heading back for the dry season centres of concentration in the Nuba Mountains, and further south to the lands close to Bahr el-Ghazal and the White Nile.

By late October the Abbala begin their trek from the northern region into the Project Area, which they enter during November. Their main groups include : The Shanabla, the Kawahla, the Kababesh, the Hawawir, the Beni Gerar, and the Diweih. The intensity of migrations varies from one year to the other, all depending on the conditions of pastures and water-supply in the northern semi-desert zone from which these groups originate. In years of good rains and abundant pastorage less populations and herds enter the Project Area; while inversely in years of Mahal (scarce pastures and water sources) the Project Area experiences heavy pressures on its available grazing and water-supply. For example the rainy season of 1981 being a bad one in the northern areas had been followed by Mahal conditions which sent into the Project

Area nomads from as far north as Ed Dabba at the bent of the Nile.

During the cool period November-December the water requirements of the camels and sheep raised by these nomads being low, herders head with their animals to the baga land (areas of extensive grazing remote from settlements) making use of the bush vegetation and visiting the nearby water-yards when need arises. Part of the reason for heading to such remote grazing areas is to avoid the encroachment of animals on the village cultivations which are not yet harvested.

By January the crops are harvested and the land becomes open for grazing. Also as from this month and on, the animal needs for water increase, thus inducing the nomads to move closer to water-points. Because of these two factors, as from January the Abbala groups shift their encampments to the vicinities of the watering-points, and begin utilizing the grazing available in the surroundings of villages. It is interesting to record in this connection the emergence in recent years of the village bur land, which is protected during the rainy season from animals by the presence of the cultivations, as an important source of grazing for the herds and flocks of the nomads during the dry season; a factor which has resulted in sending the Abbala livestock into the village lands.

The raising of animals in the Project Area has evident impacts on the degradation of its natural resources. As early back as the beginning of the 1950's, Harrison warned against the devastation that shall be caused by the uncontrolled increase in the numbers of animals, the effects of which shall spread to an unrecoverable stage by the extensive provision of water points. Thirty years later this prediction turned to be true, judged from the conditions of deterioration characterizing the Project Area at present. The theories projecting the occurrence of this vast deterioration rested on two main ideas. That increases in animals numbers without expansions in the pasturage base shall in time make the eco-system vulnerable to overgrazing beyond its resource capabilities; and that the limited grazing raduis, especially of cattle from water-yards shall lead to the creation of circles of over used land around these yards, which in time shall link with each other resulting in continuous belts of exhausted areas.

This is presently reflected in most of the Project Area. The northern parts are completely devasted, mainly due to the availability of water from open-shaft wells which can be sunk freely at almost any location in this zone. This with intensive human habitation and the raising of cattle have severely stripped off the area of its vegetation cover. Again the same phenomenon can

Table 5.10.

Population Characteristics of the Project Area.

Number of Physiographic Zone.		Village Surveyed	No. of House-holds	Total Population.	Average Size of House-hold.
I	1	Abu Sinun (Daba Nayra)	50	300	6
	2	Kabar El Haboob	20	150	7
	3	El Homour	8	70	9
	4	El Humiera	40	150	5
	5	Qeriwid	30	150	5
	6	Umm Dieika	45	300	7
	7	Kerbab	130	800	6
	8	El Rokub	50	350	7
II.	9	Faragalla	160	900	6
	10	Khor Tagat Digiel	55	320	6
	11	El Hamadiya	300	1500	5
	12	El Kharta	300	1500	5
III.	13	Sinjukai	250	1500	6
	14	Meirerha	350	1800	6
	15	Abu Saad	500	3000	6
	16	Umm Hegleig	160	800	5
IV.	17	Andraba	60	450	7
	18	Halfa	18	92	5
	19	Ereidibo	74	324	4
	20	Goz El Kursan	40	250	6
	21	Umm Kitera	20	140	7
	22	Umm Shugeira	100	600	6
	23	Fertangul	80	480	6
	24	Sweilim	75	560	7
	25	Mereikib	80	425	5
	26	Umm Arada	60	300	5
	27	El Tumeid	317	1374	4
	28	Burbur	100	600	6
V.	29	Kubbaka	100	600	6
	30	Umm El Sheikh	400	2000	5
	31	El Tibna A/Latif.	166	1000	6
	32	El Tibna /Musa	100	500	5
	33	Rihood El Nabag	50	300	6
	34	Umm Sirieha/Adam	100	500	5

Cont..

Number of Physiographic Zone.		Village Surveyed	No. of House-holds.	Total Population.	Average Size of House-hold.
	35	Umm Sirieha A/Rahim.	1040	5200	5
	36	Ghineinya	216	1300	6
	37	Shawaya	50	300	6
	38	El Odyat Adam	60	300	6
	39	El Odyat Musa	80	425	5
	40	Goz El Shaw	100	800	8
	41	Tabeldya - Mahmoud	50	350	7
	42	Shag El Windi	100	500	5
	43	Dagak	40	200	5
VI.	44	El Goghan	250	1500	6
	45	Gedgidim.	200	1000	5
	46	Koanamosa	250	1500	6
	47	Shanbani	100	700	7
	48	Rediesat			
	49	Umm Riswa	140	700	5
	50	Samandia	240	1200	5
	51	Kindua	150	800	5
	52	Umm Gezira	500	3000	6
	53	Umm Gennas	333	2000	6
	54	Tafantara	160	800	5
	55	Shebula	400	2400	6
	56	Deriesa	200	1400	7
	57	Kadada	410	2870	7
VII.	58	Umm Sot	80	400	5
	59	El Beida	85	500	5
	60	Shriem El Karamsha	140	700	5
	61	Shriem El Hamad	22	150	7
	62	Shriem El Mudier	21	150	7
	63	Umm Dabbus	80	400	5
	64	Umm Dabbus El Markha			
	65	Umm Dabbus El Gaaliein.	90	1500	6
	66	El Nala	200	1400	7
	67	Asida	100	600	6
	68	Alawaga	22	130	6
	69	Umm Hagar	40	300	7
	70	El Rokob	60	450	7

Examining the population parameter in relation to the availability of water supply i.e. the population envelopes served by the existing water points, is essential in assessing the water situation in the area, which can be used as indication of the areas faced by water shortages at present. An attempt in arriving at some indices of the areas served by the existing water-points is made in Fig. 13 worked out from survey data.

Besides the settled population the Project Area accomodates the groups of Baggara and Abbala nomads who visit it alternately during wet and dry season. It is difficult to supply accurate statistics for the nomads numbers, since they constitute parts of larger census areas that extend beyond the Project boundaries; besides the fact that their numbers vary from one year to the other, depending on the grazing and water-supply conditions inside and outside the Project Area. Some estimates of the nomads numbers based on the 1973 Census are given in Table 5.11.

Table 5.11.
Estimates of Nomads Numbers.

Tribal Group.	Total Population	Population entering Project Area.
1. Hawazma, Nuba, Bederiya.	60,000	30,000
2. Habbaniya, Direihmat	20,000	10,000
3. Shanabla	20,000	20,000
4. Kawahla, Kababesh, Hawawir, Beni Gerar, Diweih.	200,000	20,000
Total		80,000

Table 6.2.

Number of Tins of Water Consumed in Wet Season - Daily.

No. of Tins. / Zones.	1-4 No:	%	5-9 No:	%	10-14 No:	%	15-19 No:	%	20 + No:	%	Do not Know. No:	%	TOTAL. No.	%
I	3	20.0	7	46.7	3	20	-	-	2	13.3	-	-	13	100
II	5	16.7	10	33.3	8	26.7	3	10	-	-	4	13.3	20	100
III	8	27.6	14	48.3	2	6.9	2	6.9	1	3.4	2	6.9	29	100
IV	10	18.2	29	52.7	10	18.2	2	3.6	3	5.5	1	1.8	55	100
V	5	16.1	12	38.7	6	19.4	1	3.2	1	3.2	6	19.4	31	100
VI	13	40.6	12	37.5	1	3.1	1	3.1	1	3.1	4	12.5	32	100
VII	1	4.8	10	47.6	8	38.1	-	-	1	4.8	1	4.8	21	100
Total	45	21.1	94	44.1	38	17.8	9	4.2	9	4.2	18	8.5	213	100

found to be 9 tins daily. This amount seemed to be large in such an area where water collection is rather difficult but it is clear that not all the amount reported is used for domestic purposes. Some respondents reported watering some animals at home. There is also a wide variation in the amount of water consumed according to zones.

The present amount of water consumed is limited by a number of factors. The most important factor is difficulty in getting the required amount of water which is reported by 24.6% of the respondents. That difficulty may be the result of difficulty in transporting water or too much time wasted in the journey between home and water sources. Other respondents reported many factors as shown in Table 6.3.

Water fetching is a difficult job involving time, effort and economic costs. All members of the family are involved in water fetching at different degrees. The most important water collectors are children (29.2%). It is also found that 26.3% of the family heads are involved in water fetching (Table 6.4).

Small number of respondents (28.2%) reported buying water from water vendors. These water vendors are of two types; lorry owners who transport water to cisterns in the village and sell it at high price to consumers

Table 6.3.

Why the Present Amount of Water is Used.

Zones	Water not enough.		Difficult to get		Source too Crowed		Too Expensive		It is the needed		Bad taste.		Water source/far		others		Total	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%
I	1	7.7	8	61.5	-	-	-	-	-	-	-	-	2	15.4	2	15.4	13	100
II	8	25.8	2	6.5	-	-	18	57.5	-	-	1	3.2	-	-	2	6.5	31	100
III	-	-	5	26.3	1	5.3	-	-	-	-	-	-	8	42.1	5	26.3	19	100
IV	13	28.3	8	17.4	15	32.6	2	4.3	1	2.2	1	2.2	5	10.9	1	2.2	46	100
V	5	20.8	5	20.8	-	-	-	-	-	-	1	4.2	10	41.7	3	12.5	24	100
VI	7	22.6	12	38.7	2	6.5	2	6.5	2	6.5	-	-	4	12.9	2	6.5	31	100
VII	-	-	2	28.6	-	-	1	14.3	4	57.1	-	-	-	-	-	-	7	100
Total	34	19.9	42	24.6	18	10.5	21	13.6	7	4.1	3	1.8	29	17.0	15	8.8	171	100

or cart owners (Caro) selling water to households. The first type is widespread in Zone I and II where water is very scarce and the second type is mainly found in Zone VI. Because of the high cost of water from water vendors, the amounts bought are rather small (Table 6.5).

The respondents gave many reasons for buying water from vendors. The most important reason is lack of transport (52.2%) and no family member available because children go to schools.

The amount of water consumed at the household may be influenced by price of water in the source. As a result of problems of lack of fuel and spare parts, water from the wateryards is becoming precious. The survey showed that more than 51.00% of the respondents pay more than 25 p.t. daily to get water. This represent a very high proportion of their income (Table 6.6).

The amount of water consumed is also found to be influenced by the location of the source with respect to place of residence. Villagers with a water source in their village spend little time in water fetching. In the Project Area it is found that more than 33% of the respondents spend more than two hours to get water to their homes while only 18.8% spend about half an hour. The time spent may be as a result of distance or difficulty in getting water because the wateryard is too crowded (Table 6.7).

Table 6.5.

Number of Tins of Water Bought from Vendor Daily.

No. of Tins / Zones	1-4 No.	1-4 %	5-9 No.	5-9 %	10-14 No.	10-14 %	15-19 No.	15-19 %	20 + No.	20 + %	Don't Know No.	Don't Know %	TOTAL. No.	TOTAL. %
I	6	60.0	1	10.0	3	30.0	-	-	-	-	-	-	10	100
II	7	23.3	12	40.0	8	26.7	2	6.7	1	3.3	-	-	30	100
III	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IV	-	-	1	100	-	-	-	-	-	-	-	-	1	100
V	4	40.0	6	60.0	-	-	-	-	-	-	-	-	10	100
VI	7	71.8	1	11.1	-	-	-	-	-	-	-	-	9	100
VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	24	40.0	21	35.0	12	20.0	2	3.3	1	1.7	-	-	60	100

Table 6.6.

Amount of Money Paid for Water Daily.

Amount in p.t: / Zones.	1-4 No.	1-4 %	5-9 No.	5-9 %	10-14 No.	10-14 %	15-19 No.	15-19 %	20-24 No.	20-24 %	25 + No.	25 + %	TOTAL No.	TOTAL %
I	6	54.5	1	9.1	2	18.2	-	-	-	-	2	12.2	11	100
II	-	-	1	3.4	-	-	-	-	-	-	28	96.6	29	100
III	-	-	6	37.5	2	12.5	1	6.3	6	37.5	1	6.3	16	100
IV	-	-	-	-	5	20.0	6	24.0	5	20.0	9	36.0	25	100
V	1	12.5	1	12.5	-	-	-	-	-	-	6	75.0	8	100
VI	-	-	-	-	-	-	-	-	1	12.5	7	87.5	8	100
VII	-	-	-	-	6	75.0	1	12.5	-	-	1	12.5	8	100
Total	7	6.7	9	8.6	15	14.3	8	7.6	12	11.4	54	51.4	105	100

Table 6.7.

Time Spent in Getting Water.

Time in Hours / Zones	½		½ - 1		1-1½		1½-2		2 +		Don't Know		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	1	6.7	1	6.7	1	6.7	1	6.7	10	66.7	1	6.7	15	100
II	9	34.6	1	3.8	6	23.1	2	7.7	8	30.8	-	-	26	100
III	5	17.2	5	17.2	1	3.4	1	3.4	17	58.6	-	-	29	100
IV	14	25.5	18	32.7	7	12.7	8	14.5	8	14.5	-	-	55	100
V	1	3.3	5	16.7	5	16.7	2	6.7	17	56.7	-	-	30	100
VI	1	3.2	10	32.2	7	22.6	5	16.1	8	25.9	-	-	31	100
VII	8	38.1	2	9.5	7	33.3	2	9.5	2	9.5	-	-	21	100
Total	39	18.8	42	20.3	34	16.4	21	10.1	70	33.8	1	0.5	207	100

Those villagers living away from the source may make only one trip every two days (8.7%) or one trip daily (21.7%) while most of the respondents make one to two trips daily. Thus the number of trips is influenced by the distance of the water source and mode of transport (Table 6.8).

The amount of water brought to the household is used for different domestic purposes (Appendices IV, V, VI, VII, VIII, IX, X, XI) Animals are normally watered in the waterysrd and the amount consumed is judged by the amount of money paid (Tables 6.9 and 6.10). In the wet season about 33% of the respondents stated that they water their animals in the waterysrd. Those are respondents living in the sandy areas where ponds are not found.

Consumers normally choose the type of source they consider to be the best to satisfy their needs. This choice is exercised in areas where more than one source is found. But in the Project Area more than 82.00% of the respondents reported that they use the source because it is the only source (Table 6.11). Very few reported that they use the source because they consider its water to be healthy.

Table 6.9.

Number of Tins of Water Consumed Daily in Watering Animals.
(Dry Season)

No. of Tins / Zones	1		1-2		3-4		5-6		7-8		9-10		10 +		Don't Know		TOTAL	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%
I	5	38.5	4	30.8	1	7.7	1	7.7	-	-	-	-	1	7.7	1	7.7	13	100
II	6	37.5	1	6.3	3	18.8	6	37.5	-	-	-	-	-	-	-	-	16	100
III	3	15.8	7	36.8	5	26.3	2	10.5	-	-	1	5.3	-	-	1	5.3	19	100
IV	3	16.7	9	50.0	3	16.7	-	-	-	-	-	-	3	16.7	-	-	18	100
V	11	44.0	6	24.0	3	12.0	1	4.0	-	-	-	-	-	-	4	16.0	25	100
VI	6	46.2	4	30.8	2	15.4	1	7.7	-	-	-	-	-	-	-	-	13	100
VII	5	35.7	6	42.9	2	14.3	-	-	-	-	-	-	1	7.1	-	-	14	100
Total	39	33.1	37	31.4	19	16.1	11	9.3	-	-	1	0.8	5	4.2	6	5.1	118	100

Table 6.10.

Number of Tins consumed Daily in Watering Animals.

(Wet Season)

No. of Tins / Zones.	1		1-2		3-4		5-6		7-8		9-10		10 +		Don't Know.		TOTAL	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No.:	%
I	1	14.3	2	28.6	2	28.6	-	-	-	-	-	-	1	14.3	1	14.3	7	100
II	3	50.0	1	16.7	1	16.7	-	-	-	-	-	-	-	-	1	16.7	6	100
III	1	10.0	6	10.0	1	10.0	1	10.0	-	-	-	-	-	-	1	10.0	10	100
IV	4	25.0	8	50.0	-	-	4	25.0	-	-	-	-	-	-	-	-	16	100
V	4	21.1	3	15.8	1	5.3	-	-	-	-	-	-	-	-	11	57.9	19	100
VI	5	71.4	1	14.3	-	-	1	14.3	-	-	-	-	-	-	-	-	7	100
VII	1	14.3	4	57.1	1	14.3	-	-	-	-	-	-	1	14.3	-	-	7	100
Total	19	26.4	25	34.7	6	8.3	6	8.3	-	-	-	-	2	2.8	14	19.4	72	100

Table 6.11.

Reasons for Using the Mentioned S urce for Drinking.

Reasons / Zones	Only Source.		Near to House.		Easy to Get.		Clean		Healthy.		Free of Charge.				Good Taste.		Others		TOTAL	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No.	%
I	15	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	100
II	20	66.7	6	20.2	3	10.0	-	-	-	-	1	3.3	-	-	-	-	-	-	30	100
III	20	69.0	1	3.4	-	-	1	3.4	2	6.9	-	-	-	-	4	13.8	1	3.4	29	100
IV	55	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55	100
V	31	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31	100
VI	25	78.1	2	6.3	5	15.6	-	-	-	-	-	-	-	-	-	-	-	-	32	100
VII	10	47.6	1	4.8	7	33.3	1	4.8	-	-	2	9.5	-	-	-	-	-	-	21	100
Total	176	82.6	10	4.7	15	7.0	2	0.9	2	0.9	3	1.4	-	-	4	1.9	1	0.5	213	100

This discussion showed that there are many factors influencing water consumption in the Project Area. The most important factors are distance of the source and shortage of water supply. These two factors are reported by 43.4% of the respondents. There is also a zonal variation. In zone I, 82.6% of the respondents reported that these are the two most important factors (Table 6.12). This result points to areas of deficiency and areas where water is needed most. It is clear that villagers in zones I, III and V are in need for water improvement to meet the present and future needs.

In other zones, the respondents are worried about their future supplies. Nearly 91% stated that the present sources are not enough to meet the future demands because of the natural increase of population and animals in the village and immigration to villages with adequate water supplies (Table 6.13). This table supports the argument stated earlier that permanent water sources attracts services and migrants from areas of deficiency leading to population and animal concentration beyond the carrying capacity and thus deterioration in environmental conditions.

Table 6.12.

Factors Limiting Water Consumption.

Factors / Zones	Water not enough.		Difficult to get water.		Source is too crowded.		Too Expensive.		Water not Clean		Bad taste		Water Source too far.		Much time wasted		Other Factors.		TOTAL.	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No.	%	No:	%	No.	%	No.	%
I	8	34.8	3	13.0	-	-	1	1.3	-	-	-	-	11	47.8	-	-	-	-	23	100
II	7	17.1	5	12.2	1	2.4	25	61.0	-	-	-	-	2	4.9	-	-	1	2.4	41	100
III	5	14.3	3	8.6	10	28.6	3	8.6	-	-	-	-	13	37.1	1	2.9	-	-	35	100
IV	15	25.9	5	8.6	18	31.0	5	8.6	-	-	-	-	9	15.5	4	6.9	2	3.4	58	100
V	13	30.2	7	16.3	1	2.3	3	7.0	-	-	-	-	13	30.2	5	11.6	1	2.3	43	100
VI	5	16.1	15	48.4	2	6.5	3	9.7	-	-	-	-	4	12.9	2	6.5	-	-	31	100
VII	1	5.6	7	58.9	3	16.7	1	5.6	-	-	-	-	2	11.1	2	11.1	2	11.1	18	100
Total	54	21.7	45	18.1	35	14.1	41	16.5	-	-	-	-	54	21.7	14	5.6	6	2.4	249	100

Table 6.13.

Reasons Behind Future Water Deficiency.

Reasons / Zones	More people are settling.		Population Growing.		Large Number of Animals.		Nomads use the source.		Service attract more people.		Good Agric. land attract People.		Low performance of source		Others		TOTAL.	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No.	%
I	10	38.5	8	30.8	3	11.5	3	11.5	-	-	-	-	2	7.7	-	-	26	100
II	12	24.0	16	32.0	12	24.0	2	4.0	-	-	-	-	4	8.0	4	8.0	50	100
III	4	10.0	18	45.0	11	27.5	-	-	-	-	-	-	4	10.0	3	7.5	40	100
IV	15	25.0	22	36.7	6	10.0	4	6.7	-	-	-	-	15	21.7	-	-	60	100
V	9	21.4	14	33.3	5	11.9	2	4.8	1	2.4	1	2.4	8	19.0	2	4.3	42	100
VI	16	41.0	13	33.3	5	12.8	1	2.6	1	2.6	-	-	1	26	2	5.1	39	100
VII	6	25.0	8	33.3	5	20.8	3	12.5	-	-	-	-	2	8.3	-	-	24	100
Total	72	25.6	99	35.2	47	16.7	15	5.3	2	0.7	1	0.4	34	12.1	11	3.9	261	100

Another factor mentioned by the respondents as influencing their future supplies is the low performance of the source because the pumps are old, tanks and taps are not in a good condition. They even suggest ways to improve the situation (Table 6.14). It is clear that 59% of the respondents think that a new wateryard will solve the present and future demands. Most villagers in zones I, III, IV and V, aspire for a wateryard while in zones VI, and VII prefer shallow wells as a solution. Thus those living in areas where most of the water supplies come from hafirs and did not experience major environmental degradation suggest wateryards, while there in environmentally degraded areas as in zones VI and VII suggest shallow wells. This result must have a very important planning implication. It shows the degree of awareness with respect to environmental degradation and also willingness to accept water sources that provide limited amounts of water. Another interesting feature appears in answers report by villagers in zone I. In this zone the suggestions for hafirs and wateryards have equal weight (42.1%). This zone is one of the difficult areas where groundwater is difficult to find, thus some of the respondents became aware of this fact and look forward for a hafir as a solution to their future demands.

Table 6.14.

Suggestions to solve the Water Shortage.

Suggestions / Zone.	New Water-yard. No:	%	New shallow well. No:	%	New Big Tank No:	%	Change Pumps. No:	%	Change Manage-ment. No:	%	Improve Mainten-ance. No:	%	Provide Petrol No:	%	Hafirs No:	%	Others No:	%	TOTAL No:	%
I	8	42.1	3	15.8	-	-	-	-	-	-	-	-	-	-	8	42.1	-	-	19	100
II	17	53.1	6	18.8	-	-	-	-	-	-	2	6.3	-	-	7	21.9	-	-	32	100
III	24	85.7	3	10.7	-	-	-	-	-	-	1	3.6	-	-	-	-	-	-	28	100
IV	37	86.0	4	9.3	-	-	-	-	-	-	2	4.7	-	-	-	-	-	-	43	100
V	21	67.8	2	6.5	-	-	-	-	-	-	2	6.5	-	-	5	16.1	1	3.2	31	100
VI	8	25.8	13	41.9	-	-	-	-	-	-	-	-	-	-	10	32.3	-	-	31	100
VII	2	16.7	10	83.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	100
Total	117	59.7	41	20.9	-	-	-	-	-	-	7	3.6	-	-	30	15.3	1	0.5	196	100

The respondents also gave their reasons behind prefering the source suggested. The most important reasons are permanancy of the source and provision of more water (Table 6.15). But the villagers in zone VII think the source they suggested (shallow wells) will help in stopping environmental degradation.

Respondents Evaluation of Water Sources :

In this section we try to examine the respondents' evaluation of the water they use with respect to amount, quality, taste and colour. The importance of this is to know the type of source perceived to be the best and accordingly planners must adjust their plans according to local initiation or device methods of convincing the local inhabitants that the source they suggested is either not feasible or of bad quality leading to health problems. Through this method local involvement will be felt from the planning stages.

Perception of a source is a personal evaluation influenced by the individuals personal characteristics, past experience, educational level and age. Based on these factors the individual makes a choice if more than one source is available or pass his judgement on the type of water he uses.

Table 6.15.

Reasons for the Preference of the Mentioned Source.

Reason / Zones	Efficient.		Permanent Supply.		Clean water		Healthy water		Provides more water		Easy to obtain water.		Stops deterioration.		Others		TOTAL	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%
I	4	22.2	7	38.9	1	5.6	1	5.6	3	16.7	2	11.1	-	-	-	-	12	100
II	3	10.3	10	34.5	-	-	-	-	10	34.5	4	13.8	-	-	2	6.9	29	100
III	-	-	3	9.7	-	-	1	3.2	17	54.8	7	22.6	-	-	3	9.7	31	100
IV	6	11.1	17	31.5	3	5.6	-	-	23	42.6	1	1.9	-	-	4	7.4	54	100
V	8	20.5	14	35.9	-	-	-	-	10	25.6	7	17.9	-	-	-	-	39	100
VI	2	6.3	16	50.0	-	-	-	-	6	18.8	6	18.8	-	-	2	6.3	32	100
VII	-	-	1	9.1	-	-	-	-	1	9.1	-	-	8	72.7	1	9.1	11	100
Total	23	10.7	68	31.8	4	1.9	2	0.9	70	32.7	27	12.6	8	3.7	12	5.6	214	100

In the Project Area, it is found that there is a zontal variation in perception with regard to the variables investigated (amount, quality, tase and colour). It is found that most of the respondents except in zone VII think that the amount of water available is not enough (Table 6.16) and they think that its taste is good, but there is some variation with regard to colour, because large numbers use hafirs with brownish water.

With regard to quality there is also some variation in perception. Most of the respondents in all zones perceive the water they drink as of good quality, but appreciable number in zone I, where most of the water is provided by hafirs think that the quality is bad (Table 6.17).

Improvement of water quality is recognised to have health benefits. To what extent the local inhabitants are aware of this, is examined by a series of questions. The respondents reported many diseases as prevalent in their area (Table 6.18). They attribute the causes to many factors among which is bad water (Table 6.19). It is found that only 16% think that bad water or the water they drink may cause diseases. They consider dirty water or saline water as the main causes of diseases (Table 6.20).

Table 6.18.

Types of Reported Diseases.

Disease / Zones.	Malaria		Bilharzia.		Fever		Stomach troubles		Kidney troubles		Eye		Diabria		Others		TOTAL	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No.:	%
I	11	78.6	-	-	-	-	2	14.3	-	-	-	-	1	7.1	-	-	14	100
II	14	51.9	-	-	5	18.5	1	3.7	-	-	1	3.7	1	3.7	5	18.5	27	100
III	10	41.7	-	-	5	20.8	1	4.2	1	4.2	1	4.2	-	-	6	25.0	24	100
IV	14	36.8	-	-	11	28.9	5	13.2	-	-	-	-	2	5.3	6	15.8	38	100
V	14	58.3	1	4.2	2	8.3	2	8.3	1	4.2	1	4.2	-	-	3	12.5	24	100
VI	15	53.6	-	-	1	3.2	3	10.7	1	3.6	3	10.7	1	3.6	4	14.3	28	100
VII	14	77.8	-	-	-	-	1	5.6	-	-	-	-	1	5.6	2	11.1	18	100
Total	92	53.2	1	0.6	24	13.9	15	8.7	3	1.7	6	3.5	6	3.5	26	15.0	113	100

Table 6.19.

The Causes of Reported Diseases.

Causes / Zones.	Mosquit-oes.		God's will		Flies.		Bad Food		Bad Water		Too Much Work		Others		Total	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No.	%
I	10	66.7	1	6.7	-	-	2	13.3	2	13.3	-	-	-	-	15	100
II	12	46.2	3	11.5	-	-	1	3.8	-	-	6	23.1	4	15.4	26	100
III	5	25.0	5	25.0	-	-	1	5.0	3	15.0	4	20.0	2	10.0	20	100
IV	5	14.7	8	23.5	-	-	-	-	3	8.8	11	32.4	7	20.6	34	100
V	5	22.7	3	13.6	-	-	-	-	4	18.2	5	22.7	5	22.7	22	100
VI	10	43.5	5	21.7	-	-	-	-	1	4.3	4	17.4	5	13.8	23	100
VII	2	11.8	2	11.8	-	-	-	-	-	-	10	58.8	3	17.6	17	100
Total	49	31.2	27	17.2	-	-	4	2.5	13	8.3	40	25.5	24	15.3	157	100

Table 6.20.

The Types of Water Perceived as Causing Diseases.

Cause / Zones	Saline		Dirty		Animal and people use the same trough.		Others.		Do not know		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	-	-	3	100	-	-	-	-	-	-	3	100
II	-	-	3	50.0	1	16.7	2	33.3	-	-	6	100
III	5	62.5	2	25.0	-	-	-	-	1	12.5	8	100
IV	2	50.0	-	-	2	50.0	-	-	-	-	4	100
V	1	8.3	8	66.7	2	16.7	1	8.3	-	-	12	100
VI	-	-	1	100	-	-	-	-	-	-	1	100
VII	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	8	23.5	17	50.0	5	14.7	3	8.8	1	2.9	34	100

It is clear that very few who are really aware of the relationship between water and health. This is so because the water they drink is either rain water collected in hafirs or underground water and both are considered as free of any contamination. The situation is assessed differently when animals and people use the same trough. Animals like sheep, goats, cattle and camels are thought to be clean and thus no danger to humans when they share the same trough while donkeys, and horses are considered dirty. But despite this perception, it is found that animals of all sorts share the same trough. Also around these troughs, heaps of animal waste are found and with water spillage create a muddy condition and increasing the danger of water contamination. Thus the methods of water collection and animal watering in wateryards must be changed in order to reduce the possibility of contamination.

As stated earlier, the villagers perceive the water they drink as being safe (Table 6.21). This is so because it is clean, and of underground or rain origin,(Table 6.22). Respondents in zone I where hafirs are the only sources, describe their water as clear and safe because it is of rain origin.

Table 6.21.

Is the Water you drink Safe ?

Zones	Yes		No		Don't Know		TOTAL	
	No.	%	No.	%	No.	%	No.	%
I	12	80.0	3	20.0	-	-	15	100
II	26	86.7	3	10.0	1	3.3	30	100
III	20	69.0	8	27.1	1	3.4	29	100
IV	53	96.4	2	3.6	-	-	55	100
V	17	54.8	14	45.2	-	-	31	100
VI	31	96.9	1	3.1	-	-	32	100
VII	21	100	-	-	-	-	21	100
Total	180	84.5	31	14.6	2	0.9	213	100

environmental changes that may occur as a result of water provision.

This discussion concentrated to a large extent on water demand and available supplies as well as the methods of water collection and costs. The costs enables us to point to some aspects which have relevance to the project. These could be grouped under the following :-

1) It is found that the amount of water consumed by the average household is high and there are signs that it will increase in the future. Therefore any improvements in water supplies must take into consideration the future demand. Therefore the design and capacity of the water source must take into consideration these facts.

2) This chapter showed one of the main limiting factors to more water consumption - which is desirable - is the distance of the water source from place of residence. This fact must be taken into consideration in site selection.

3) It is also found that children are the most important water collectors. Thus future designs of wateryards must consider this fact e.g. more taps and platforms that help children to perform their duties easily.

4) It is also found that water costs in this area are very high. Thus we have to strike a balance between more

water provision to reduce the cost and the concern for environmental conservation. This balance may be found if we deviced methods enabling us to provide each village with its water source.

5) Very few respondents are aware of the relationship between water and health. Thus there is need to link water programmes to programmes on sanitation education to raise the level of awareness and teach simple methods of water purification while persuing this line there is need to consider the traditional methods of water purification in order to assess their influences and possible improvements.

6) The study showed that there is a high degree of environmental awareness among the local inhabitants and we feel that this awareness may be utilized to implement the control measures suggested in another chapter.

7) Water provision attracts services and leads to concentration of animal and human populations. This fact may be tied to an strategy aiming at creating growth points where investment is concentrated so as to create centres which attract and hold economic activity and therefore hold population. In this respect water supply projects are to be seen as part of an overall strategy aiming at rural development and growth of infrastructure.

CHAPTER VII

MANAGEMENT OF RURAL WATER SUPPLIES IN KORDOFAN.

It is recognized that the degree to which a water supply system fulfils its function varies almost directly with efficiency and effectivencse of its management. The management of a rural water supply system is seen as composed of three interrelated stages; planning, construction and operation and maintenance. To achieve these functions, appropriate structures must be established linking national plans and objectives to the needs and requirements of the local community. The most important and serious function appears after the construction of the water system mainly operation and maintenance. In most cases that function is neglected during the planning stages and more concern is given to operation and maintenance only after problems start to arise.

In this part we are going to deal mainly with the administration of the water sources at the local level, because other aspects of management, manpower requirements, training, planning procedures- are beyond the scope of this study.

The structure of rural water administration and type

of control in Kordofan, witnessed many changes similar to what happened in other parts of the country when management problems became very serious as a result of the construction of a large number of water sources beyond the cabability of the Rural Water Development Corporation (RWDC). However, in this province the RWDC was responsible for planning, construction, operation and maintenance of the wateryards while the administration of the water sources was given to rural councils. This procedure continued up to March 1982 when the RWDC (now called National Administration for Water - NAW) decided to take over full responsibility over wateryards from all technical as well as administrative aspects.

Before the take over, water sources faced many problems. Experience showed that many rural councils failed in the proper management of water sources for the following reasons :-

1. They were unable to create strong body to supervise the operation and maintenance of the wateryards.

2. They even failed in the field of revenue collection which was left under the control of some clerks and accountants without close supervision.

3. The greatest failure was in the field of maintenance and petrol provision. This led to general deterioration in the water supply system to the extent that a large number of waterpoints were not operating during the survey.

4. Rural councils were given the responsibility of administration and revenue collection while RWDC was responsible for the eechnical aspects such as construction and maintenance. This sharing of responsibility without clearly defining the role of each organization contributed effectively to the unsatisfactory conditions of water sources.

Despite these problems, in the field of water administration, the experience and the hardships faced by the villagers created new awaroness towards village water supplies. Slowly village councils and village organizations began to be involved in water supply problems and device measures to solve them. As a result of this the local community started to feel some attachment to the water source and developed a sense of ownership. The local organization were able to mobilize the community and through self-help contributions, they were able to pay for petrol,maintenance and

to improve the condition in the wateryards. To achieve this each village formed the organization which they feel that it is able to deal with these problems. Thus in some villages, special water committees were formed while in others organizations such as village councils or Development Committees took over the responsibility of involving the local community in the water supply problems.

Despite the success of these organizations in keeping the water system operating, they also have their problems. Field investigation showed that these local organizations have limited technical and administrative abilities to supervise and control the water source. Beside these, in many cases local factions and differences may play a destructive role in the administration of the wateryard. However the survey found many successful cases.

Management problems arise as a result of the high costs of administration as maintenance. These costs vary according to the type of the source and location in relation to maintenance centres. These costs may be divided into two parts; direct and indirect costs. The direct costs include expenditure on items like spare parts, oils, fuel and salaries, while indirect costs include maintenance, supervision, training of personnel

and depreciation of mechanical parts. The total expenditure on both direct and indirect costs increased dramatically. According to NAW (1981) the total costs of administeration and maintaining one wateryard was Ls.2,900 in 1975. In 1980 the cost was more than Ls.6,000 while the revenue collected was about Ls.3,000. Thus it seems that lack of funds contributed effectively to the poor condition of the existing wateryards. Other sources of water supplies - hafirs, dams and improved shallow wells - require little operation costs.

This discussion allows us to make a summary of the main management problems faced in this area; these include :-

1. Lack of funds.
2. Lack of trained personnel especially at maintenance centres and at local level.
3. The newly built maintenance centres and workshops are still idle because of the lack of logistical support and skilled labour.
4. Problems of fuel, oils and spare parts.
5. Pumps are old and of different types and brands complicating the problems of spare part supply and trained labour availability.
6. Bad means of communication to report breakdowns.

7. Maintenance teams are not well equipped to enable them to handle problems of breakdowns.
8. Local involvement and participation not well organized and properly utilized.

Evaluation of the Type of Control and Water Administration in the Project Area :

In the project area, the main problemsthat face water supply sources especially wateryards are found to include problems of maintenance, lack of spare parts and fuel shortage. The combined effect of these problems is manifested in the large number of water-yards found not working during the survey (50%). The main factor for this high rate is that most of the pumps vary in age and make. They range from engines made in 1930 to new reciprocating pumps. Their make also vary from old English Lister types to those made in Yougslavia or Scandinavian countries or India.

The extent of these problems is shown in the following table (7.1) which indicates clearly the extent of mechanical breakdowns especially in zones where the main water sources are wateryards. A large number of villages reported (other) problems. These

include delay in repairs, irregular opening hours, favouratism and corruption at wateryard level.

Table 7.1

Villages Reporting the Type of Management Problems according to physiographic Zones.

Zone / Problem	Breakdown	Fuel Shortage	Management not Friendly	Others
I				100%
II				100%
III	50%			50%
IV	50%	50%		
V			50%	50%
VI	100%			
VII			30%	70%
VIII		40%		60%

As a result of these problems a large number of villagers started using or repairing the old unimproved sources exposing themselves to serious health hazards.

The villagers have their ideas with regard to steps to be taken to improve water supply situation in their village. Most of their suggestions revolve around providing a new source rather than rectifying the old. (Table 7.2).

Table 7.2.

Suggestions to improve the Present Water Situation in the Villages According to Physiographic Zones.

Zone	New Borehole %	Additional Borehole. %	Shallow well %	Hafir %	Improve Maintenance %	Bigger Tank. %	New Pump %	Bring water by Tankers. %	Others %
I	14.2	--	--	57.1	--	--	--	28.5	--
II	33.3	33.3	--	--	33.3	--	--	--	--
III	80	--	--	20	--	--	--	--	--
IV	--	--	33.3	33.3	33.3	--	--	--	--
V	18.7	--	12.5	25.0	12.5	12.5	--	12.5	--
VI	13.3	46.6	13.3	--	20.0	--	--	--	6.6
VII	25.0	--	75.0	--	--	--	--	--	--
VIII	75.0	--	--	--	25.0	--	--	--	--

The table also shows a great change in the villagers thinking and aspirations concerning the type of source. Previously, any village looked forward to have its water-yard. Shallow wells and hafirs were considered inefficient and provide unhealthy water. But as a result of the serious problems facing the wateryards with regard to petrol provision and maintenance, hafirs and shallow wells seem to be appropriate alternatives. Also some villagers, especially those owning small number of animals or those more concerned with the protection of their Hashab gardens, see shallow wells and hafirs as the best way to stop environmental degredation because the water they provide is rather limited and the efforts involved in getting water do not attract nomads or animal owners.

Closer look to Table clearly reveals these charges. Villagers in zones I, II and III live in an area of Basement Complex where underground water is difficult to find. Thus nearly all water sources in these zones are either hafirs or shallow wells and some villages are provided by tankers or have cisterns. The environmental condition is well preserved with plenty of pasture and vegetation cover. For this reason they do not see more water as endangering their environment, so they still aspire for boreholes of hafirs. Villagers in zone IV and VII occupy Umm Ruwaba series where most

of the wateryards are found. These areas face a number of environmental problems, especially removal of vegetation cover, overgrazing,overcultivation and low yields. As a result of these pressures, they started to feel that more water leads to more environmental degredation. Thus most of them suggested shallow wells or improving the maintenance situation as a way to improve environmental conditions and water supply situation. Villagers in zone V and VI occupy an area underlain by Basement Complex and the main soil type is clay. All drinking water sources in these two zones are either hafirs or shallow wells. Few boreholes are found in Wadis and along fault lines. The environment is moderately degreded. Thus large number of villagers aspire for boreholes while others see shallow wells as a solution to their water supply problems.

This result, as indicated earlier, shows a major change in villagers aspirations and choice of the water source. It seems that most of the villagers became aware of environmental degredation around them and they attribute the cause to water supply in unlimited quantities. This trend could be utilized by the water providing agency to implement control measures in order/to

reduce the negative impact of rural water supplies. The result shows clearly the willingness of the villagers to accept and use water provided by sources other than boreholes and will accept measures to reduce the negative impact of water if wisely implemented and clearly explained to them.

supply programme, depends on the extent to which society is considered during the planning stages(Y.A.Mohamed, 1982). Local involvement is very important if the local inhabitants are to feel a responsibility for some common useful resource such as pumps and water installations. Water provision must not be seen as a donor-to-government operation, but as donor to people (C. Widstrand 1978). This in turn means that planning and siting of supplies must start from below and considering the people's wishes. Thus national programmes must take into consideration the following variables :-

a) Priority areas.

b) Level of service to be provided.

c) Participation of the beneficiaries.

In the Sudan in general and in the project area in particular, institutionalized participation in water provision is rather new, but self-help in its traditional form is very old and it is part of the rural life. Self-help in its traditional or institutionalized form shows the people's level of involvement in domestic water supply. While in its institutionalized form, it is a substitute to full government control over water provision and management.

In the project area, self-help and local involvement is still not well organized and institutionalized. In fact, and since independence (1956) there was no serious effort by the government to involve the local people in water programmes, because the financial ability of the government was far below the aspirations of the villagers. Thus at that period local participation took the form of delegates sent to press for a water source or provision of food and hospitality to those involved in site selection or building the water source.

By 1970 the government considered self-help and local involvement as a mechanism to provide more services to rural areas. Thus a number of village organizations were formed to mobilize the local resources and reduce

reliance on the government especially in service provisional development projects.

The involvement of these organizations in the field of water supply provision became very clear when problems of management and fuel provision became very serious. Still this participation is not institutionalized in the project area. It depends on local initiative and the co-operation of the wateryard administration. An assessment of these organizations is necessary to evaluate their ability and their role with respect to water provision. This assessment is necessary because we feel that local participation and involvement is very important in any future water development project and in the implementation of any control measures that may be suggested by NAW to reduce the negative environmental impacts or to control water provision. On the other hand if NAW opt for a policy of decentralization, local involvement becomes essential.

Generally, in the project area, there are a number of organizations at the village level managing the affairs of the local community and involved at different levels in water supply problems. In some villages special committees are formed "water committee" whose

main function is to help the waterpoint administration in solving problems of maintenance, spare parts and fuel provision.

The study looked into the different forms of community organizations in the project area and found that there are about six organizations at the village level (Table 7.3)

The table reveals that the village councils and development committees are the most wide spread organizations and they are almost found in more than 50% of the villages in the project area. On the other hand wateryard committees are found in few villages where water supply is utilized by persons coming from other surrounding villages. It was also found that wateryard committees and village councils shoulder the responsibility of mobilising the local resources in solving the water source problems. During the survey it was found that the most pressing problem facing the wateryard committees and village councils was how to keep the wateryards functioning. Thus the dominant activity was how to raise self-help money to meet the rising costs of fuel, spare parts and other needs of the wateryard (Table 7.4).

Table 7.3.

Villages Reporting the Presence of the following Organizations according to Physiographic Zones.

Zone	Village Council	Village Development Committee.	Co-op Society	Youth Association	Parent's Committee.	Wateryard Committee	Others
	%	%	%	%	%	%	%
I	37.5	31.2	18.7	--	12.5	--	--
II	44.4	33.3	--	22.2	--	--	--
III	50	--	12.5	--	25.0	12.5	--
IV	52.6	10.5	10.5	5.2	15.7	--	5.2
V	46.8	15.6	18.7	12.5	3.1	--	3.1
VI	39.4	10.5	5.2	7.8	15.7	7.8	13.1
VII	57.1	14.2	14.2	--	--	7.1	7.1
VIII	57.1	--	14.2	14.2	14.2	--	--

Table 7.4.

Role Played by the Village Organizations in the Management of the Water Source According to Physiographic Zones.

Zone	Collect Self-help	Organize Water Collection	Bring Petrol	Report Breakdowns	Collect Money for Maintenance.	Organize any Self-help	Others.
	%	%	%	%	%	%	%
I	33.3	16.6	--	--	10.6	33.3	--
II	40.0	--	20.0	--	20.0	20.0	--
III	18.1	9.0	27.2	9.0	18.1	18.1	--
IV	--	37.5	--	--	62.5	--	--
V	20.0	40.0	--	--	20.0	20.0	--
VI	26.4	8.8	26.4	8.8	17.6	11.7	--
VII	40.0	10.0	--	--	10.0	30.0	10.0
VIII	28.5	--	28.5	14.2	28.5	--	--

Most of the villagers surveyed seemed to be happy with the performance of their organizations in water management, because these organizations consult them in any activity to get their agreement. Also they see the fruits of their action in form of spare parts or fuel for the water yard (Table 7.5).

Table 7.5
Percentage of Villages reporting satisfaction with the performance of organizations involved in water management.

Zone	Yes	No
I	100%	- -
II	50%	50%
III	100%	- -
IV	75%	25%
V	66.6%	33.3%
VI	100%	- -
VII	100%	- -
VIII	- -	100%

Wise policy for rural water provision requires the full support of the beneficiaries. This type of policy involves participation from planning stages through construction and finally management. Most of the villages

(61.5%) studied reported their participation in the planning stage. The form of participation varies from one village to the other. In some it involves mere consultation with regard to site of the wateryard, in others it may be as major as transporting some equipment or buying cement or cash contribution.

These facts show the willingness of the villagers to participate effectively in water provision as well as water management. In the field of water management most of the local participation takes the form of cash contribution. The most popular procedure followed by the village organization is to get the support of the villagers to levy extra charge per tin of water to be used to buy fuel, spare parts and to pay maintenance costs. Cash contributions take four forms :-

a) Fixed amounts of money collected when need arise e.g. in case of breakdowns, shortage of fuel or to buy spare parts.

b) Extra charges on water taken from the source collected by the clerk of the wateryard of wateryard committee.

c) In some cases some villagers agree to raise the price of some rationed commodities such as suguar,

tea etc, and use the money collected in self-help projects including maintenance and operation of the wateryard.

d) Fixed amounts of money to be paid by each family in the village.

Generally each village device the method appropriate to the economic condition of the inhabitants but all of them try to avoid direct cash collection because it involves much work and rather unpopular.

Effectiveness of Self-help :

Villagers through their contributions are actually fulfilling a desire. Water provision is considered as a pre-requisite to developments but the improvement of that source to meet standards set by somebody from outside the community is not a priority. This is why there is much enthusiasm and participation in water provision in villages with no water while villages with water supplies concentrate their efforts on establishing other services and not to improve the existing source. In the project area the survey team found one village only that tried to reduce the distance of the source by installing standpipe in the village.

Self-help has increased the capabilities of the rural people and generated a feeling of self-reliance.

The effectiveness of self-help is tied to factors such as degree of local support to new village organizarions or the strength of tradition, tribal loyalities, religious affilations and village factions. The spread of the village organizations and its competition with the traditicnal leaders may reduce the effectiveness of self-help and village participation. In spite of this fact the different organizations as well as the traditicnal leaders were able to mobilize the local resources and change the attitude of the villagers towards services provided by the government because they contributed effectively in their construction or maintenance.

It seems that what is lacking is a clear policy towards village involvement in the administration of water sources. There must be some attempts by NAW to create the appropriate organizations to help in the management of the water sources. The created organizations must be organized,guided, and supported technically and financially. This policy must clearly outline the role of the village organizations and the degree of support they are expected to get from the government.

Summary and conclusions :

When considering management we have to divide the functions into two divisions; the first deals with administration and the second deals with operation and maintenance. In achieving both functions the survey showed the importance of local participation so as to ensure effective utilization of the source and to reduce chances of misuse. In this section a summary of the main findings and recommendations is given.

a) Operation and Maintenance :

1. The study showed the need that operation and maintenance must be considered from the planning stages not to be neglected until problems arise.

2. Operation and maintenance must be decentralized. The study found appropriate action in this direction, but the centres established are still idle.

3. Operation and maintenance is permanent feature of the rural water programme and so its continuity depends on the existance of appropriate organizational structure and trained personnel capable to deal with water supply problems.

4. There must be a well defined maintenance programme that checks the conditions of the wateryards even if no breakdowns reported.

5. To establish an effective means of reporting any breakage.

6. Operations and maintenance involves two things :(i) equipment and (ii) operators and technical personnel. In both aspect NAW possesses experience and technical expertise to perform them efficiently. Thus newly created maintenance centres and workshops must be supplied with logistical support to enable them to move quickly to where they are needed.

b) Administration :

1. The survey found that the administration of the wateryard is controlled by three persons namely the Clerk (effendi), the Guard (Ghaffir) and Operator. This procedure excludes the local community from supervising the wateryard and will not create a sense of "owning" among the villagers. This policy must be changed in favour of local participation. There is no universal technique for involving the local community in water supplies, but the experience of the last years shows the ability and willingness of the local inhabitants and their organizations in taking good care of water administration. The agency providing water should look for the appropriate organization and leadership to

either shoulder the responsibility of water administration alone or to help the wateryard administration.

2. The unified water pricing system is not appropriate and it should abandoned in favour of multi-level system depending on the ability to pay.

3. The survey found that the village organizations and development committees are involved at different levels in the administration of the wateryards. As these committees are also performing other functions it seems appropriate to create special "Village Water Committees" and give them the full responsibility of water administration while maintenance is performed by NAW through its district centres and the committee pays the costs from revenue collected. This system requires clear identification of the responsibilities of the Village Water Committees and NAW.

CHAPTER VIII

MONITORING PROGRAMME

The base line survey assessed the water resources in the project area with respect to its adequacy, habits of use and consumption patterns and its environmental impacts. We have to confess that in our analysis we stressed the negative impacts but without totally ignoring the positive aspects. This is so because these negative impacts are more prominant. Closer examination will reveal that the efforts in water provision resulted in time saving and made life more easier in the rural areas. The health impacts are difficult to quantify as well as difficult to give a monetary value to ease of life. However, assessment and evaluation of both positive and negative impacts are very important so as to take the appropriate remedial measures, because it is more expensive to rectify damages and it is cheaper to take anticipatory remedial measures. The right step in this direction starts with monitoring the changes that take place. This could be achieved by a resurvey of the water source (wateryards) taking the initial planning data as base line and compare the changes-positive or negative- that took place after water provision. In this respect we

have to state that it may not be appropriate to relate all changes to water provision. There may be other variables and forces working together to effect the changes monitored. To seperate the important factors is the job of the analyst. Our aim here is to provide a comprehensive list of the variables for an on-going monitoring programme in the project area. The unit of the section recommended to be created in NAW must shoulder this responsibility.

During the survey, information on indicators of environmental changes was gathered. The most prominant indicators are reported here for monitoring. The list of potential indicators is divided into three sections; pysical, biological and social.

1. Physical Indicators :

1. Rainfall

Rainfall in such marginal areas plays a very important role in the social and economic well being of the inhabitants. Despite this fact rain guages are limited to towns only. For the purpose of monitoring more rain guages must be placed in the different zones. This could be done with the collaboration of the meteorological service.

2. Soils

a) Soil erosion as a result of human use.

b) Soil structure and texture.

c) Soil fertility.

d) Changes in soil moisture content.

e) Percentage of bare soil around radius or six Kms. of wateryard.

3. Winds and Habcobs

a) Frequency and speed.

b) Impact on soils.

4. Water Courses and drainage pattern.

a) Flooding.

b) Change in direction of flow.

5. Water levels during the dry season especially in shallow wells.

2. Biological Indicators :

1. Vegetation cover with respect to :-

a) Changes in vegetation species.

b) Trees - especially failure to regenerate.

c) Density of grasses and shrubs assessed as (high,medium,low).

d) Invasion of unplatable species.

e) Dissappearance of some platable species.

f) Changes in fodder needs and the appearance and use of substitutes to natural forage.

g) Outbreak of fires.

h) Spread of termites.

2. Livestock :

a) Areas of concentration during wet and dry seasons.

b) Number of livestock.

c) Changes in the pattern of nomadic imigration.

d) Migration of village herds.

f) Selling of livestock(more selling at low prices).

g) Milk supply(judged from its prices).

h) Outbreak of animal diseases.

3. Agriculture :

a) Changes in crop distribution and combination.

b) Declines in crop yields.

c) Introduction of new crops.

d) Changes in crop rotation.

e) Changes in the pattern of local cultivation (trend towards continuous use of crops).

f) Changes in crop prices.

g) Changes in land tenure (selling and renting of land).

h) Clearance of new areas for cultivation.

i) Clearance of Hashab gardens for cultivation.

j) Appearance of parasitic plants (Buda).

k) Appearance of pests and diseases.

3. Social and Economic Indicators :

a) Increase or decrease in population.

b) Age/Sex structure of population (e.g. young males 20-35 are absent).

c) Migration rate.

d) Increase in animal numbers (sheep, goats and camels).

e) Number of tankers or lorries carrying water.

f) Number of charcoal burning and wood cutting permits.

g) Change towards the use of less desired wood in cooking or charcoal making.

h) Number of lorry loads of charcoal from the area.

i) Selective use of trees-diminishing number of certain species (for building, etc.).

j) Increasing distance from settlement to get wood and grasses.

k) Distance of pasture from water source (if distance increased for settled herd, range degredation close to the water source is likely).

l) Tree felling for fodder.

m) Presence of nomadic tribes in village lands.

n) Human diseases - decrease or increase of water related diseases.

Wateryard :

a) Date of erection.

b) Actual pumping hours.

c) Actual opening hours.

d) Amount of water consumed daily.

e) Average number of people using the wateryard for different months.

f) Average number of animals using the water-yard for different months.

g) Number of villages using the wateryard.

h) Months of water shortage - Reasons.

i) Reasons for shut down.

j) For how long the wateryard is closed.

k) Community reaction to shut down.

l) General condition of the wateryard (fence, taps, mud, pumps, tanks, etc.).

m) Water prices.

n) Revenue collected.

APPENDIX II

ON THE CREATION OF WATER AUTHORITY FOR KORDOFAN REGION

The results of this survey showed clearly the negative impacts of rural water supplies on the ecosystem. These negative impacts are expected to have wide implications on the natural resources of the area and leads to further environmental degredation. In this respect further rural water development requires greater co - ordination with departments and agencies involved in national resource management. On the other hand, the regional administration for water must strengthen its capabilities to carry out water assessment studies to ensure maximum development of water resources in the region. This requires thinking in terms of the entire groundwater basins and watershed management. It is clear that such approach on water provision and natural resource management can only be achieved through compentent co-ordinating body that involves all administrations and departments dealing directly with water provision or water related matters and resource management. On the other hand, the water providing agency must periodically review its policies and evaluate its activities. This

analysis and pericdical assessment will help in the forcast of future requirements and demands.

To achieve these objectives we suggest the creation of a body called "Kordofan Water Development and Utilization." The proper functioning of such body can only be realized, if such an institution is based on legal provisions.

Such provisions are embedded in the following Act;[1/]

Name of the Act and its application

Article 1) This Act is called "Kordofan Water Development and Utilization" Act, 1983 and it is applicable once it passed the Regional Assembly and Signed by the Regional Government.

Board Establishment

Article 2) According to this Act a board should be established called the Kordofan Water Development and Utilization Board. This Board is a legal body with the authority of signiture.

1/ In writing this part we made use of similar suggestions proposed for Kassala by NAW.

Article 3) 3.1 The Board consist of the follwwing

1. Commissioner of Nothern Kordofan Province. Chairman
2. Commissioner of Southern Kordofan Province
3. Director General For Water
4. Director General for Economics & Finance
5. Director General Regional Ministry of Agriculture
6. Soil Conservation Land Use and Water Programming
7. Range and Pasture Management Administration
8. Forest Department
9. Ground Water Specialist of NAW
10. Hafir Engineer
11. Senior Water Engineer, Public Electricity and Water Corporation - El Obeid
12. One representative from the different Districts - Areas

3.2 The Director General for Water should be the Secretary of the Board.

Duties of the Board

Article 4) 4.1 To formulate short and long term plans for Water development in the area. To execute the Water policy and co-ordinate the different Studies and programmes of the different governmental units and to ensure optimal exploitation of the water resources in the area.

4.2 To co-ordinate the activities of the different units involved in natural resource management with the aim of environmental protection and desertification control.

4.3 To formulate regulations in order to protect the water resources from pollution and bad usage.

4.4 To formulate regulations for enviromental protection

4.5 To secure the necessary financial means to support the Technical Committee established according to Art. 5 of this Act and to check the accounts submitted by the committee

Technical Committee Establishment

Article 5) 5.1 Technical Committee should be established in consultation with the National Administration for Water and Soil Conservation Land Use and Water Programming Administration. Head of the Technical Committee should be a Senior water engineer and the Secretary should be from Soil Conservation and Water Programming.

5.2 Members of the committee should be qualified as experienced personnel from NAW, Soil Conservation, Range and pasture management and Forest Department.

5.3 Under delegation of the Board, the committee bears and carries out the following responsibilities and tasks in co-ordination with the respective units

5.3.1 Executing the regulations set according to Art.4 of this Act.

5.3.2 Offering technical advise for government units and private enterprises regarding water and water related matters.

5.3.3 Advising in the location of new wells and boreholes

5.3.4 To carry out socio-economic and environmental studies in sites proposed for water provision and to recommend the type, capacity and control measures based on the criteria outlined before.

5.3.5 To evaluate and assess the impact of existing sources.

5.3.6 To monitor changes that take place after water provision.

5.3.7 To diffuse the results of these surveys and studies to NAW sections.

5.3.8 To supervisethe creation of water committees and guide them.

5.3.9 Keep records and files for the different water sources containing information on committees, breakdowns, spare parts,revenue collected,

5.3.10 To device methods aiming at the creation of environmental awareness among villagers.

5.3.11 Submission of yearly budget to the Board for approval and checking.

5.3.12 Issuing of licenses for drilling of boreholes to private sector.

5.3.13 Carry out hydrogeological and geophysical studies.

F i n a n c e

Article 6) The budget of the Board is from all of the following sources.

a) From the Regional and Central Governments.

b) Water license fees

c) Any aids or loans

d) Any other sources

Board Regulations

Article 7) The Board should formulate the following regulations

a) Regulations for locating water sources in accordance with environmental conditions

b) Regulations for use of natural resources.

c) Regulations of penalties.

d) Regulations for licenses of boreholes to be drilled by private sector.

APPENDIX III

On Maintenance and Spare Parts
(This information is supplied by NAW in El Obeid)

No detailed information is available about the mechanical breakage and its frequency as well as spare parts usage. In general maintenance of wateryards take place through the maintenance centres in El Obeid, Bara and Umm Ruwaba. Each centre annually receives its stock of spare parts to be used when needed, but due to the frequent breakdowns there is always delays and shortage in spare parts.

The type of engines working in the project area are Lister, Torbedo, Deutz and Shobra, while the types of pumps in use are Edeca, Scheoller, Adller and Zaraf.

Shobra type is found to be not suitable for work in this area, so it is changed by either Lister or Torbedo.

The most suitable type of pumps in use in the area, are Edeco and Scheoller and most of the spare parts requested are for these two types. (See the following tables)

Wateryards in the Project Area and Type of Pumps in Use.

Name of Location	No. of Borehole Wells.	Type of Pumps	Season of Erection	Tank Capacity Gallons.	Remarks
1. Umm Riswa	1	Lister/Zarafa	1968/69	5,000	
2. Sineen	2	Lister/Edco	1955/56	10,000	
3. Abu Girein	2	Lister/Edco	1974/75		
4. Umm Gennas	2	Lister/Edco Lister/Zarafa	1971/72 1972/73	10,000	
5. Giddedim	1	Torbedo/Scheoller	1971/72		
6. Abu Hamara	2	Lister/Edco	1953	10,000	
7. Umm Gezira	2	Lister/Edco	1953	10,000	
8. Kundua	1	Torbedo/Scheoller	1972/73	10,000	
9. Samandia	2	Lister/Edco Lister/Edco	1959 1953	10,000	
10. Umm Sereiha Bagadi	1	Torbedo/Scheoller	1979/80	10,000	
11. Tafantara	1	Lister/Zarafa	1970/71	5,000	
12. Kounamouse	2	Lister/Zarafa Lister/Zarafa	1970/71 1970/71	5,000	
13. Amanalla	1	Lister/Edco	1969/70	10,000	
14. Abu Shatir	1	Lister/Edco	1969/70	10,000	

Appendix III (Cont.).

Name of Location	No. of Borehole Wells.	Type of Pumps	Season of Erection	Tank Capacity Gallons.	Remarks
16. Derisa	1	Torbedo/Sheoller Lister/Edco	1976/77 1968/69	5,000 10,000	
17. Zureiga El Qizan	1	Lister/Edco	1968/69	10,000	
18. KHor Taqqat	4	Lister/Edco Lister/Edco Lister/Edco	1943	10,000	
19. Ben Gadid area					Private wells.
20. Khor El Abyad					" "
21. Banu					" "
22. Abu Haraz					" "
23. Kageil					" "
24. Umm Qouzein.					" "

App. III (Cont.)

Boreholes in need of Rehabilitation and Pumping Tests.

No.	Locality	Bore No.	Coordinates Long.	Coordinates Lat.	Total Depth in ft.	Static water level (ft.)	Output gph.	Observation
1	Shambati wa Fagwa	9432	-	-	571	270	2000	Pumping Test.
2	El Redaisat	9430	-	-	473	270	1800	" "
3	El Ghabsha Badeen	4832	31° 27'	12° 54'	600	-	-	Needs R.P.T.
4	Umm Gezira	9417	31° 02'	12° 58'	600	342	1500	Pumping Test.
5	El Goghan	3423	31° 12'	12° 53'	640	290	1300	R.P.T.
6	El Suema	5449	31° 41'	12° 56'	805	300	1000	Rehabilitation
7	El Eddaiyat	4885	30° 52'	12° 47'	427	290	480	"
8	Tafamtara	2937	31° 02'	13° 05'	591	310	4000	"
9	Karaginay	3888	31° 14'	12° 58'	465	180	450	"
10	Tafemlara	4893	31° 02'	13° 05'	725	-	-	R.P.T.
11	Umm Sot	A,B,C	30° 19'	13° 32'	-	-	-	" " "
12	Mileiha	A & B	30° 19'	13° 32'	-	-	-	" " "
13	Hamdan	4844			800	65	800	" " "
14	Hamdan	4902	13° 3'		775	65	960	" " "
15	Umm Gerif	2829	30° 36'	13° 31'	800	142	1440	" " "

Cont..

No.	Locality	Bore No.	Coordinates Long.	Lat.	Total Depth in ft.	Static water level (ft.)	Output gph.	Observation
16	Gambir	5495	31° 15'	14° 35'	-	-	-	R. P. T.
17	El Semeih	28	30° 51'	12° 43'	400	-	-	" " "
18	Medesis	4420	30° 32'	13° 18'	480	215	1200	Rehabilitation.
19	Kaandamousa	4446	31° 06'	12° 52'	700	300	500	"
20	Antatati A&B	4837	30° 06'	13° 35'	-	-	-	"
21	Togaza	4843	30° 40'	13° 32'	-	-	-	R. P. T.
22	Umm Sereiha	4833	30° 55'	12° 56'	560	220	-	Rehabilitation.
23	Manfoura	3424	31° 02'	13° 02'	750	301	1693	"
24	Dilgateb	4892	30° 53'	12° 57'	645	237	1250	"
25	Umm Reika	2832	30° 50'	13° 28'	404	172	720	"

R.P.T. = Rehabilitation and Pumping Test.

Table AP. III

List of Hafirs Existing in Project Area.

Hafir	Capacity M^3	Remarks
ELAIN	500,000	
AMARAD	60,000	
BIRKAELKBIRA	34,000	
MODO	23,000	
ARADEIBA	20,000	
UMM SHUGEIRA	30,000	
SHEIKAN	40,000	
BURBUR	30,000	
UMM RAMAD	25,000	
UM SAMIN	20,000	
ET TINA	30,000	
KHOR BAGARA	500,000	
ABU SINUN	15,000	
TALOSHI	15,000	
UM HEIGLEIG	19,000	
EL IDAYAT	10,000	
NAVA	10,000	Silted.
FANGOGA	20,000	"
GOZ BISHARA	14,500	"
EL SIMEIH	43,000	
EL GAFEIL	40,000	Seepage common, dry in March.

APPENDIX IV.

Water Source in Dry Season.

Type of Source / Zones	Water-yard.		Shallow Wells.		Hafir		Pond		Jammam		Others		TOTAL	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%
I	-	-	-	-	15	100	-	-	-	-	-	-	15	100
II	-	-	1	3.4	-	-	-	-	-	-	28	96.6	29	100
III	20	69.0	9	31.0	-	-	-	-	-	-	-	-	29	100
IV	55	100	-	-	-	-	-	-	-	-	-	-	55	100
V	-	-	12	36.7	19	61.3	-	-	-	-	-	-	31	100
VI	-	-	22	68.8	10	31.3	-	-	-	-	-	-	32	100
VII	8	38.1	13	61.9	-	-	-	-	-	-	-	-	21	100
Total	83	30.2	57	26.9	44	20.8	-	-	-	-	28	13.2	212	100

Water Source in Wet Season.

Type of Source / Zones	Water-yard.		Shallow Wells.		Hafir		Pond		Jammam		Others		TOTAL	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No.	%
I	-	-	-	-	15	100	-	-	-	-	-	-	15	100
II	-	-	-	-	15	51.7	13	44.8	-	-	1	3.4	29	100
III	11	37.9	8	27.6	-	-	10	34.5	-	-	-	-	29	100
IV	55	100	-	-	-	-	-	-	-	-	-	-	55	100
V	-	-	12	38.7	7	22.6	12	38.7	-	-	-	-	31	100
VI	-	-	6	18.8	7	21.9	16	50.0	-	-	3	9.4	32	100
VII	8	38.1	13	61.9	-	-	-	-	-	-	-	-	21	100
Total	74	34.9	30	18.4	44	20.8	51	24.1	-	-	4	1.9	212	100

APPENDIX V.

Number of Tins of Water Consumed Per Day in Drinking.

DRY :

No. of Tins / ZONES.	1		1-2		3-4		5-6		7-8		9-10		10 +		Don't Know.		TOTAL	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%
I	-	-	5	33.3	5	33.3	3	2.0	-	-	1	6.7	-	-	1	6.7	15	100
II	1	3.3	21	70.0	7	23.3	1	3.3	-	-	-	-	-	-	-	-	30	100
III	2	6.9	13	44.8	11	37.9	3	10.3	-	-	-	-	-	-	-	-	29	100
IV	3	5.5	21	38.2	18	32.7	4	7.3	-	-	-	-	-	-	9	16.4	55	100
V	3	9.7	17	54.8	7	22.6	-	-	-	-	-	-	-	-	4	12.9	31	100
VI	1	3.1	19	59.4	5	15.6	-	-	-	-	-	-	-	-	7	21.9	32	100
VII	-	-	7	33.3	9	42.9	2	9.5	1	4.8	-	-	-	-	2	9.5	21	100
Total	10	4.7	103	48.4	62	29.1	13	6.1	1	0.5	1	0.5	-	-	23	10.8	213	100

WET :

No. of Tins / ZONES.	1		1-2		3-4		5-6		7-8		9-10		10 +		Don't Know		TOTAL	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%
I	1	6.7	7	46.7	4	26.7	1	6.7	-	-	1	6.7	-	-	1	6.7	15	100
II	2	6.7	23	76.7	2	6.7	1	3.3	-	-	-	-	-	-	2	6.7	30	100
III	3	10.3	17	58.6	4	13.8	-	-	-	-	-	-	-	-	5	17.2	29	100
IV	5	9.1	23	41.8	14	25.5	4	7.3	-	-	-	-	-	-	9	16.4	55	100
V	4	12.9	11	35.5	6	19.4	-	-	-	-	-	-	-	-	10	32.3	31	100
VI	4	12.5	14	43.8	3	9.4	-	-	-	-	-	-	-	-	11	34.4	32	100
VII	-	-	9	42.9	8	38.1	2	9.5	-	-	-	-	-	-	2	9.5	21	100
Total	19	8.9	104	48.8	41	19.2	8	3.8	-	-	1	0.5	-	-	40	18.8	213	100

APPENDIX VI.

Number of Tins of Water Consumed Daily in Preparing Food.

DRY :

No. of Tins / Zones	1		1-2		3-4		5-6		7-8		9-10		10 +		Don't Know		TOTAL.	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No.:	%
I	4	26.7	10	66.7	-	-	-	-	-	-	-	-	-	-	1	6.7	15	100
II	11	36.7	18	60.0	1	3.3	-	-	-	-	-	-	-	-	-	-	30	100
III	14	48.3	15	51.7	-	-	-	-	-	-	-	-	-	-	-	-	29	100
IV	24	43.6	21	33.2	1	1.8	-	-	-	-	-	-	-	-	9	16.4	55	100
V	15	48.4	12	38.7	-	-	-	-	-	-	-	-	-	-	4	12.9	31	100
VI	15	46.9	10	31.3	-	-	-	-	-	-	-	-	-	-	7	21.9	32	100
VII	3	14.3	14	66.7	1	4.8	1	4.8	-	-	-	-	-	-	2	9.5	21	100
Total	88	40.4	100	46.9	3	1.4	1	0.5	-	-	-	-	-	-	23	10.8	213	100

WET :

No. of Tins / Zones	1		1-2		3-4		5-6		7-8		9-10		10 +		Don't KNow		TOTAL.	
	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No.:	%
I	4	20.7	10	66.7	-	-	-	-	-	-	-	-	-	-	1	6.7	15	100
II	12	40.0	15	50.0	1	3.3	-	-	-	-	-	-	-	-	2	6.7	30	100
III	13	44.8	11	37.9	-	-	-	-	-	-	-	-	-	-	5	17.2	29	100
IV	24	43.6	21	38.2	1	1.8	-	-	-	-	-	-	-	-	9	16.4	55	100
V	11	35.5	10	32.3	-	-	-	-	-	-	-	-	-	-	10	32.3	31	100
VI	12	37.5	9	28.1	-	-	-	-	-	-	-	-	-	-	11	34.4	32	100
VII	3	14.3	14	66.7	1	4.8	1	4.8	-	-	-	-	-	-	2	9.5	21	100
Total	79	37.1	90	42.3	3	1.4	1	0.5	-	-	-	-	-	-	40	18.8	213	100

APPENDIX VII.

Number of Tins of Water Consumed Daily in Washing Clothes.

DRY :

No. of Tins / Zones.	1		1-2		3-4		5-6		7-8		9-10		10 +		Don't Know		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	7	46.7	6	40.0	1	6.7	-	-	-	-	-	-	-	-	1	6.7	15	100
II	23	76.7	7	23.3	-	-	-	-	-	-	-	-	-	-	-	-	30	100
III	17	58.6	12	41.4	-	-	-	-	-	-	-	-	-	-	-	-	29	100
IV	38	69.1	6	10.9	2	3.6	-	-	-	-	-	-	-	-	9	16.4	55	100
V	20	64.5	6	19.4	-	-	-	-	-	-	-	-	-	-	5	16.1	31	100
VI	18	56.3	7	21.9	-	-	-	-	-	-	-	-	-	-	7	21.9	32	100
VII	12	57.1	4	19.0	2	9.5	-	-	1	4.8	-	-	-	-	2	9.5	21	100
Total	135	63.4	48	22.5	5	2.3	-	-	1	0.5	-	-	-	-	24	11.3	213	100

WET :

No. of Tins / Zones.	1		1-2		3-4		5-6		7-8		9-10		10 +		Don't know.		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	6	40.0	7	46.7	1	6.7	-	-	-	-	-	-	-	-	1	6.7	15	100
II	25	83.3	3	10.0	-	-	-	-	-	-	-	-	-	-	2	6.7	30	100
III	16	55.2	8	27.6	-	-	-	-	-	-	-	-	-	-	5	17.2	29	100
IV	38	69.1	5	9.1	3	5.5	-	-	-	-	-	-	-	-	9	16.4	55	100
V	14	45.2	7	22.6	-	-	-	-	-	-	-	-	-	-	10	32.3	31	100
VI	17	53.1	4	12.5	-	-	-	-	-	-	-	-	-	-	11	34.4	32	100
VII	11	52.4	5	23.8	2	9.5	-	-	1	4.8	-	-	-	-	2	9.5	21	100
Total	127	59.6	39	18.3	6	2.8	-	-	1	0.5	-	-	-	-	40	18.8	213	100

APPENDIX VIII.

How Many Tins will be Consumed if Water is Easily Available.

Zones / No. of Tins	1-4		5-9		10-14		15-19		20 +		Don't know		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I	-	-	1	6.7	5	33.3	4	26.7	5	33.3	-	-	15	100
II	-	-	7	23.3	14	46.7	5	16.7	4	13.3	-	-	30	100
III	2	6.9	6	20.7	13	44.8	4	13.8	4	13.8	-	-	29	100
IV	5	9.1	14	25.5	18	32.7	8	14.5	8	14.5	2	3.6	55	100
V	1	3.2	3	9.7	20	64.5	3	9.7	4	12.9	-	-	31	100
VI	4	12.9	13	41.9	8	25.8	3	9.7	3	9.7	-	-	31	100
VII	-	-	7	35.0	7	35.0	2	10.0	3	15.0	1	5.0	20	100
Total	12	5.7	51	24.2	85	40.3	29	13.7	31	14.7	3	1.4	211	100

APPENDIX IX.

Water Perception for Second Source (Amount, Taste & Colour).

	AMOUNT								TASTE								COLOUR							
	More than Enough.		Enough		Not Enough		Total		Good		O.K.		Bad		Total		Clear		Brownish		Dirty		Total	
ZONE.	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%	No:	%
I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
III	1	12.5	2	25.0	5	62.5	8	100	1	12.5	1	12.5	6	75.0	8	100	6	75.0	-	-	2	25.0	8	100
IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	-	-	1	33.3	2	66.7	3	100	-	-	2	66.7	1	33.3	3	100	1	33.3	2	66.7	-	-	3	100
VI	-	-	1	9.1	10	90.9	11	100	6	54.5	5	45.6	-	-	11	100	7	63.6	2	18.2	2	18.2	11	100
VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1	4.5	4	18.2	17	77.3	22	100	7	31.8	8	36.4	7	31.8	22	100	14	63.6	4	18.2	4	18.2	22	100

APPENDIX XI.

Income Per Family.

Amount in Ls. / Zones.	Less than 500 No.	%	500-999 No.	%	1000-1499 No.	%	1500 + No.	%	TOTAL No.	%
I	8	57.1	3	21.4	1	7.1	2	14.3	14	100
II	14	40.7	5	16.7	6	20.0	5	16.7	30	100
III	15	51.7	10	34.5	1	3.4	3	10.3	29	100
IV	23	41.8	22	40.0	5	9.1	5	9.1	55	100
V	8	26.7	13	43.3	6	20.0	3	10.0	30	100
VI	21	65.6	9	28.1	1	3.1	1	3.1	32	100
VII	12	57.1	6	28.6	2	9.5	1	4.8	21	100
Total	101	47.9	68	32.2	22	10.4	20	9.5	211	100

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